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REPORTS

TO THE

LOCAL GOVERNMENT BOARD

ON

PUBLIC HEALTH AND MEDICAL SUBJECTS.

(NEW SERIES No. 63.)

Report to the Local Government Board upon the available data in regard to the value of boiled milk as a food for infants and young animals. By Janet E. Lane-Claypon, M.D., D.Sc. (Lond.).

LONDON:
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE.
To be purchased, either directly or through any Bookseller, from
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OLIVER AND BOYD, TWEEDDALE COURT, EDINBURGH; or
E. PONSONBY, LTD., 116, GRAFTON STREET, DUBLIN.

PRINTED BY
DARLING AND SON, LTD., BACON STREET, E.
1912.

Price Ninepence.

Report to the Local Government Board upon the available data in regard to the value of boiled milk as a food for infants and young animals. By Janet E. Lane-Claypon, M.D., D.Sc. (Lond.).

Arthur Newsholme,
Medical Officer,
February 24th, 1912.

(This report embodies the result of an inquiry undertaken in connection with the Board's Grant for Auxiliary Scientific Investigations.)

Part I.—Introduction.

There is common agreement as to the great superiority of breast milk, or of the milk of the same species, over milk obtained from any other source, as a food for infants and young animals. As will be shewn in this report, experimental evidence confirms the conclusion derived from clinical experience as to the superior results obtained by feeding infants or young animals with the breast milk of an animal of the same species, instead of with the milk of another species, and emphasises the opinion that infants should be fed on the breast unless there is an urgent reason to the contrary. There remains, however, a small minority for whom artificial feeding is necessary; these infants receive, for the most part, cows' milk in one form or another; and for them the question as to the relative nutritive value of raw and boiled milk is of great importance. The consideration of this question forms the subject of the present investigation.

This subject has assumed an important aspect, owing to the intimate connection between artificial feeding and excessive mortality among infants.

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(22306—21.) Wt. 27944—566. 1000. 3/12. D & S.

Artificial feeding appears to have been introduced about the middle of the 18th century ([32]).* In the Middle Ages suckling seems to have been continued much longer than at present, its duration being considerably shortened as soon as artificial feeding became known.

Our knowledge of the degree of infantile mortality in the Middle Ages and later is necessarily very defective, owing to the incompleteness and unreliability or absence of records. There seems little doubt that the mortality among young children was extremely high.

Malthus ([45]) says "In London, according to former calculations, one half of the born died under three years of age ; in Vienna and Stockholm under two ; in Manchester under five ; in Norwich under five ; in Northampton under ten." He speaks frequently of the high mortality in foundling hospitals and similar institutions, and says "The child is taken under the protection of the parish, and generally dies, at least in London, within the first year."

It has been shown ([51]) that a high mortality among young children is in direct relationship to the mortality among infants. It is therefore highly probable that in the pre-statistical period the mortality among infants was very high. It is also probable that the prolonged suckling was as injurious to both the mothers and children of those days as it is now, and that it played a not unimportant part in the production of a high mortality among young children.

Artificial feeding spread, as was only natural, most rapidly in foundling hospitals and similar institutions ; as a result, the death-rate, which was already high (cp. Malthus, quoted above), rose to an alarming extent, and regulations were enforced in regard to the breast-feeding of infants.

Towards the end of the 19th century it was discovered that milk contained large numbers and varieties of bacteria, and that the tubercle bacillus was not infrequently one of them.

The practice of boiling milk was introduced in order to destroy the bacteria. The movement started in Paris in the year 1892 by Prof. Budin ([12, 13]) for distributing boiled milk to artificially-fed babies spread rapidly both in France and Germany. In a large number of places boiled or sterilised milk was distributed to artificially-fed children, *under medical supervision*. The results surpassed all expectations, and it was hoped that a remedy for preventable infantile mortality had been found. These hopes have not been entirely justified. Recent researches upon infantile mortality have shown that many factors are concerned in the causation of a high infant death-rate. The experience and knowledge gained by the modern schools of pediatricians have shown that regulation of the food, and other points apparently insignificant, are often of great importance.

When it was found that the giving of boiled milk did not alone prevent excessive infantile mortality, the question arose as to whether some vital properties of the milk were destroyed by heating. Much work has been done in investigating this point, as will be seen from the following pages of this report. It is to be regretted that the problem has not infrequently been obscured by

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* The small figures in brackets refer to the bibliography on pp. 57–60.

expression of opinions not based on carefully ascertained facts. In this report all known facts will be considered which bear on the general effects produced by feeding young animals upon either raw or boiled milk. This report does not deal with the experimental evidence as to the digestibility of raw and boiled milk as tested in the laboratory, the effects produced in milk by boiling, by boiling it for prolonged periods, or by heating it to a temperature above the boiling point of milk.

Confusion has been caused by the lax use of the term "sterilised milk." "Sterilised milk" in the true sense of the word is difficult to obtain; milk which has been heated to 100° C. is not sterilised, and even considerably higher temperatures are not sufficient to kill the spores which are almost always present ([31]).

In the literature of the subject, milk which has been brought to the boiling point of water is often described as "sterilised milk." This is a misnomer—it should be described as "boiled."

Investigation of the problem.

The milk given to a child or young animal may be the milk of its own species, or of another or foreign species. The problem can therefore be dealt with under two main divisions:

(1) The comparative nutritive value of raw and boiled milk of the same species.

(2) The comparative nutritive value of raw and boiled milk of a foreign species.

Both these divisions of the subject will be influenced by subsidiary factors, such as the age of the young animal or child, the quantity and quality of the milk given, and the environment or social condition.

Division (1) is chiefly applicable to cattle and will be dealt with in Part II. (see p. 4). It has also a limited applicability to the human species; this is dealt with fully in Part III. (see p. 15 et seq.).

Experiments have been carried out upon animals for the elucidation of the problem enunciated in Division (2), and will be discussed fully in Part II. (see p. 7 et seq.). The most important aspect of Division (2) concerns the artificial feeding of infants with raw or boiled cows' milk. The clinical evidence upon this matter is dealt with in Part III. and further clinical data, studied expressly for the purpose of this report, are considered fully in Part IV.

The clinical requirements for the elucidation of the problem appear to be

(1) A large number of healthy babies under medical supervision, and of known, and so far as possible, the same social environment, who shall have been fed for prolonged periods upon raw or boiled cows' milk.

Further there should be a control of babies drawn from the same average population fed in different ways.

Infant Consultations alone provide material of this type. Here the babies are approximately healthy, sick babies being referred to the hospital; they are under medical supervision, notes and records being kept; this means that the infant's food is regulated, and its general conditions noted. Further the babies are visited in their own homes by the health visitors of the Consultation, so that the social environment is known.

Application was made to the large Infant Consultations of this country, but although very friendly replies were received from the

heads of the Consultations, either the numbers of babies were quite insufficient, or some other essential data were lacking.

Only in New York is raw milk supplied in any large quantities, all the large Consultations in Europe supplying boiled milk or ordering the milk to be given boiled.

The hope of procuring a series of babies fed upon raw cows' milk had to be abandoned, and attention was directed to the collection of evidence as to a series of babies which had been fed upon boiled cows' milk, the other conditions being also fulfilled, and to the comparison of these with another series of babies representing the average baby of the district, the last series serving as a control.

From experience gained when travelling abroad as Jenner Research Scholar, I decided to apply to the Infant Consultations in Berlin.

Professor Finkelstein, Director of the Kinderasyl, and Dr. Ballin, the Director of the Municipal Infant Consultation in the Naunyn Strasse, both most kindly and courteously placed their valuable material at my disposal.

As the material of the Consultation seemed to fulfil the requirements in some ways better than that of the Kinderasyl, I availed myself of Dr. Ballin's rich and most carefully tabulated material.

I am happy to have this opportunity of thanking both Prof. Finkelstein and Dr. Ballin most heartily for their kindness, not only in placing their material at my disposal, but also for the many offers of assistance they were good enough to make me.

The material and method of dealing with it will be considered fully in Part IV.

Part II.—Experimental Evidence.

The experimental evidence may be grouped under the two divisions stated on p. 3.

The main evidence relating to the relative value of the raw and boiled milk of the same species is obtained from experiments upon calves.

The prevalence of tubercle among cows and its transmission to the calves by the milk has raised the question of the value of boiled cow's milk as a food for calves to one of great importance in cattle-rearing and dairy-farming.

Div. I.—*The effect of feeding calves upon boiled cows' milk.*

It has not infrequently been stated that calves do not thrive upon boiled cows' milk. The experiments which have been carried out hardly, however, support these assertions. Gerlach ([33]) found that calves fed upon boiled milk from birth did not do well after about four days. All trouble ceased, however, after the addition of Sodium Chloride, and the calves did excellently upon the boiled milk. After about a year, calves fed by this method again began to do badly, and it was ascertained that the salt had been omitted. These facts are very interesting, especially in conjunction with the experiments of Hittcher, recorded on page 6.

The experiments of Price ([56]) and of Doane and Price ([24]) in America certainly point to there being a disadvantage in the *sterilisation* of cows' milk. This food produced diarrhœa in some of the calves used.

Calves were also fed upon raw, boiled or pasteurised milk or sterilised milk, by Price, who found that the calves fed upon raw milk did the best. Four calves were used, and were fed for three days at a time upon the different forms of milk. Sterilised milk produced scouring in three out of the four calves. This milk was heated to 190° F. for ½-hour.

No data are given as to the age of the calf or the amount of milk given.

One of the calves was found to digest the sterilised milk as well as the other forms of milk.

H. H. Dean ([23]) carried out some work upon calves fed upon raw and pasteurised skim milk. He used four calves ; two were fed for the first four weeks of the experiment upon raw, and two upon pasteurised milk. After a week's interval the feeding was reversed, and those which had received raw milk now received pasteurised milk and *vice versâ*. The calves also received other food. The weights of the calves and the weight of food taken were recorded. Dean concluded that no difference between the two kinds of feeding could be detected, and recommended the pasteurising of skim milk before it is given to calves.

A successful campaign has been waged in Denmark against tuberculosis, under the auspices of Prof. Bang ([2]) of Copenhagen, by the simple process of boiling the milk of tuberculous cows before giving it to the calves. Unfortunately no data as to the weight or rate of growth of the calves during the course of the feeding with boiled milk are available. I am informed by Prof. Bang that the method has now been applied in many hundreds of cases, and has been found to be entirely satisfactory. The calves are taken away from the tuberculous mother at birth, and are fed for two days upon raw cows' milk, after which they receive the milk of their tuberculous mother, either boiled or raised to a temperature of 80° C.

Hittcher ([37]) has carried out some valuable work upon the value of boiled and raw cows' milk as a food for calves, with and without the addition of certain salts. He first ascertained which salts would restore to boiled milk the property of clotting with rennet. He then performed a series of experiments in the course of which 72 calves were fed upon raw and boiled milk, to which in many cases one of these salts had been added. Full data are given, and the results tabulated. The table shows not only the weights of the calves, but also the solids contained in the milk taken, and the amount of milk taken by the calves of each series, in order to put on 1 kilo. of body-weight.

Some of the experiments were carried out over a period of 10 weeks and others over a period of 15 weeks.

The age of the calf is shown to be of great importance in dealing with the nutritive value of the food. Thus a group of four calves which received raw milk and chalk required 9·01 kilos. of milk in order to put on 1 kilo. of body-weight in the first five weeks of life, and required 14·99 kilos. of milk for the same increase in body-weight on the second five weeks of life.

If these two periods are taken together, then 12·08 kilos. of milk are required for 1 kilo. increase of body-weight.

Another set of six calves which were fed upon *boiled* milk and chalk required 13·23 kilos. of milk during the first period of five weeks and 13·25 kilos. for the second period, in order to add 1 kilo. to their body-weight.

The net results of both periods shows a slight difference in favour of the raw milk, but Hittcher justly points out how great the error might have been in drawing deductions from either period taken alone.

The table given by Hittcher, which is here reproduced in full, shows that the addition of salts is a more important factor than the actual boiling of the milk. The kilos. of milk are calculated from the values of total solids obtained by actual analysis, on the basis of milk containing 11·5 per cent. of solids.

Table of results obtained by Hittcher.

Calves.		Food given.	Kilos of milk required to produce 1 kilo. of body-weight.	Daily increase		Daily food in per cent. of body-weight (in kilograms).
Group No.	No. used.			In grammes.	Per cent.	
9	3	Boiled milk and $Ca_3(PO_4)_2$	8·87	775	161·4	1·36
10	3	Raw milk and Formalin ...	10·16	702	126·6	1·32
8	3	Boiled milk and $Ca_2H_2(PO_4)_2$	10·21	687	142·5	1·45
7	5	Raw milk and NaCl ...	10·21	866	119·3	1·315
3	6	Boiled milk and NaCl ...	10·45	803	120·1	1·317
2	7	Boiled milk alone	10·82	790	119·5	1·38
1	6	Raw milk alone	11·11	798·5	127·6	1·45
5	6	Boiled milk and Ca Citrate	11·66	697	110·1	1·38
12	4	Raw milk and $CaCO_3$ ...	12·08	863	182·3	1·93
6	6	Boiled milk and $CaH_4(PO_4)_2$	12·17	675	103·6	1·40
4	6	Boiled milk and $CaCl_2$ ...	12·59	644	107·1	1·448
11	6	Boiled milk and $CaCO_3$ ...	13·13	876	151·7	1·92

Hittcher's table cannot be summarised ; it must be studied for itself in detail. He has arranged it so that there is an ascending series of figures under the heading of the amount of milk required to produce one kilogram of increase of body-weight.

If this be taken as the main criterion of the nutritive value of any food-stuff then the striking fact appears that the addition of salts is of much greater importance than the question as to whether the milk is given raw or boiled. It is difficult to estimate the value of the figures in the other columns in comparing the results of each series with one another. If in Groups 1 and 2 the amount of milk required to produce one kilogram increase in body-weight is considered, it is then seen that less of the boiled milk is required than of the raw milk ; that is, the boiled milk would appear to be more nutritious.

Owing, however, to the paucity of data dealing with the amount of milk required to give an increase of one kilogram of body-weight, it has been necessary throughout this report to take the gain in absolute weight, as the criterion of nutritive value. Upon this

basis, if the Groups 1 and 2, and 7 and 3, be examined, then there appears to be some advantage in favour of the raw milk over the boiled milk of the same species.

The salt-content of the milk is evidently of great importance. If the addition of salts to mother's milk can bring about such striking differences, then that difference in salt-content, which is known to exist between the milks of different species of animals, may reasonably be expected to play an important part in the nutritive value of the milk of a foreign species.

Hittcher justly emphasises the importance of conducting experiments over a long period of time, and of estimating daily the solid value of the food taken and not merely taking the weight of liquid milk given.

The work of Bang and Hittcher points to the conclusion that no serious loss of nutritive value is produced by the boiling of milk of the same species.

Div. II.— *Experimental evidence upon the nutritive value of the raw and boiled milk of a foreign species.*

There are several sources of fallacy in the work which has been carried out upon this subject, and it is difficult to decide which of them is the most important and which of them is the most commonly found.

One of these fallacies arises from neglect of the *chemical composition of the milk of the species selected for the experiment.*

Hittcher's experiments, quoted on p. 6, show the extreme value of the salt-content in considering the nutritive value of milk. The salt-content of the milks of different species is known to differ very greatly, and this must therefore affect the value of the milk for another species. Further the caloric value of the milks of different species is known to differ within very wide limits, and is presumably adapted for the needs of the particular species. Thus Pröscher ([56]) has shown that the chemical composition of milk varies with the normal rate of growth of the species. He estimated the rate of growth of different species by finding the time taken by that species before the initial weight at birth was doubled. On this basis he found that the rate of growth had a close relationship to the amount of protein present in the milk of the species. The quicker the rate of growth the greater the percentage of protein present.

It appears fairly evident therefore that the milk of one species cannot necessarily be considered as suitable for any other species, taken at random, and it may be supposed that the milk of a slow-growing animal will probably not have a chemical composition which will render it a suitable food for a rapidly growing species. Before endeavouring to ascertain the relative value of raw and boiled milk of a foreign species it is important to be quite sure that the milk of the foreign species selected is a suitable food for the species upon which the experiments are to be carried out. Yet, as will be seen in considering the experimental evidence in detail, these important points have been entirely ignored by some observers ; while others, having discovered this after the experiments had failed, have themselves drawn attention to these points.

Another source of error is in the age of the animal.

The length of suckling varies so greatly in different animals that the state of metabolism of the young of different species at the same age after birth, cannot be considered to be necessarily at all comparable. In many of the experiments, animals have been taken after the age of suckling and therefore at an age when their metabolism is probably very different from that of animals still in the early stages of suckling. Yet these results have been taken as comparable for the study of the nutritive value of raw and boiled milk. An animal capable of utilising a mixed diet, does not give a strictly accurate comparison with an animal capable only of utilising milk.

A further source of error lies in *the very small number of animals* which have been used by many of the observers. Where only one animal for each series of experiments is used, the sources of fallacy are so great as to vitiate in a high degree the value of the experiments.

In many cases these sources of error have been recognised by the observers themselves, but only after the experiments had been carried out.

A large variety of animals have been used by different observers for the purpose of carrying out the experiments upon the subject of the nutritive value of raw and boiled milk, namely, guinea-pigs, rabbits, mice, rats, puppies, kittens, pigs, and goats. The experiments upon each species of animals will now be considered chronologically.

Experiments upon guinea-pigs.

The first experiments carried out upon guinea-pigs were those of Bolle ([6]). Bolle (1903) was led to carry out his experiments as the result of seeing a case of Barlow's disease in a child, which he attributed to the sterilised milk upon which the child had been fed.

This observer fed young guinea-pigs upon cows' milk which had been boiled for 5, 10, 15 minutes and longer. He found that only the guinea-pigs who were fed upon the milk which had been boiled for five minutes did well; all the others died in periods varying inversely with the length of time for which the milk had been boiled. These results were sharply criticised by Bartenstein, who, on the publication of Bolle's results had commenced experiments upon the same lines.

Bartenstein ([3]) (1905) fed numerous young guinea-pigs upon raw, boiled and sterilised cows' milk. They all died. He then varied the diet, by adding to it small quantities of sterilised hay, but the animals refused the hay, and all died. Bartenstein then applied to Bolle for details in regard to the feeding. Bolle replied that the feeding had been supervised by another observer, who was no longer available for information; that there had been a little difficulty in getting the animals to feed at first, but that it had been overcome by giving cream. No observer has confirmed Bolle's results, and not much stress can be laid upon them.

Brüning ([11]) (1906) fed guinea-pigs upon raw and boiled cows' milk, using breast-fed guinea-pigs as controls. Profiting by Bartenstein's experience, he allowed all the animals small quantities of hay every

day. All the animals lived. The controls did best of all, next came the animal fed upon boiled cows' milk, and then the one fed upon raw cows' milk. The coats of the artificially-fed ones were not in good condition. Only one animal was used for each of the series, and the possibility of error is therefore very great.

Moro ([48]) (1907) fed considerable numbers of guinea-pigs upon human milk, and on cows' milk, both raw and boiled. All the guinea-pigs died in a few days, with acute symptoms suggestive of alimentary intoxication. Post-mortem examination gave no evidence as to the cause of death. Later, Moro succeeded in keeping guinea-pigs alive who were taken away from their mother immediately after birth, but were given a low vegetable diet. He then allowed the young ones to have mothers' milk for periods of 0, 1, 3, 5, 7 days, and so on. The young guinea-pigs were then isolated and given a vegetable diet. Of those taken away immediately after birth 80 per cent. died, of those left one day 30 per cent. died, of those left three days only 10 per cent. died, and of those left for longer periods *all* lived.

The weight-curves of the animals showed a progressive improvement with the length of time they were allowed to be with their mother; the superiority of the curve persisting up to the 60th day of life, when the experiment was discontinued.

These experiments show that guinea-pigs will not live upon a milk diet alone, but that they must have vegetable food. I can also personally confirm this fact, from some experiments carried out by me at the Lister Institute in 1908. (Unpublished.)

Further the period of suckling in the guinea-pig during which it receives no other form of food, is very short.

For these reasons guinea-pigs are not suitable animals upon which to carry out feeding experiments as to the nutritive value of raw and boiled milk, even apart from the question of the suitability of the milk of the particular species used. No deductions of any value can be drawn from them as to the relative value of raw or boiled cows' milk in infant feeding.

Experiments on mice.

In 1904 Keller ([39]) published some experiments on mice. Like those of Bartenstein on guinea-pigs, they were carried out as a result of Bolle's work, and were conducted by him personally or under his immediate supervision.

The mice were fed upon raw milk, upon milk just boiled, and upon milk which had been boiled for two hours. He found no difference between the mice of the different batches. Some digestive disturbances were present, but these were obviated by preventing the contamination of the food by fæces.

Experiments on rats.

Some experiments were carried out by myself ([41]) on rats, but the animals though young were no longer of an age when suckling is necessary. The rats were fed in batches of one dozen upon raw, boiled and dried milk, and a little bread. In one series those fed upon dried milk showed a slightly more rapid gain in weight than those fed upon boiled milk, and these again a rather more rapid gain than those fed upon raw milk. In two other series

fed upon raw and boiled milk respectively, no difference could be detected between the rats of either series.

The sources of fallacy in deducing from these experiments any results bearing on the feeding of infants, are, that the rats were no longer of suckling age, and that they received bread as well as milk. As, however, all the batches received the same percentage of milk and bread per kilo. of body-weight, it may reasonably be inferred from these experiments that rats just past the suckling age are able to utilise dried and boiled milk fully as well as raw milk.

Experiments on rabbits.

It appears that rabbits are scarcely suitable animals for the purposes of such experiments, nor are they at all easy to use.

It is very difficult to get young rabbits to drink out of a bottle; also rabbits' milk is much richer in fat than cows' milk and thus complications are introduced as to the amount of food required to supplement mothers' milk.

Brüning ([11]) (1906) carried out some experiments upon young rabbits, five days old. One rabbit of the litter was left with its mother, another was given raw cows' milk with the addition of cream, and the other boiled cows' milk also with the addition of cream. The rabbit fed upon raw milk died upon the eleventh day of the experiment, and the one fed upon boiled cows' milk was in a greatly inferior condition to the one left with its mother. No comparisons are possible between the effects of the raw and boiled cows' milk.

Moro ([48]) (1907) fed young rabbits upon both human and cows' milk raw and boiled. Nearly all the animals died, in spite of the fact that they took the food well. If they were allowed mixed feeding of rabbits' milk and cows' milk they rarely showed any untoward symptoms, and if these occurred the attack was warded off by stopping the cows' milk and giving only mothers' milk. The addition of cream and sugar to the cows' milk gave better results and the animals lived longer. It seems therefore that young rabbits do not thrive either on raw or boiled cows' milk or human milk, and hence are not suitable for deductions as to the relative nutritive value of raw and boiled cows' milk as a food for infants.

Experiments on dogs.

A considerable number of experiments have been carried out upon dogs, and cows' milk seems to be a suitable food for this species.

Rodet ([58]) (1896) took six puppies—four of one litter (dogs 1–4) aged from 5–6 weeks old—one of another litter of the same age (dog 5) and another rather older (dog 6).

Puppies 1 and 2 were fed upon raw cows' milk.
Puppies 3 and 4 were fed upon cows' milk, just boiled.
Puppy 5 was fed upon cows' milk subjected to prolonged boiling.
Puppy 6 was fed upon cows' milk just boiled, as for puppies 3 and 4.

As regards weight the balance was distinctly in favour of the boiled cows' milk, the increase in weight at the end of 31 days, when the experiment was terminated, being in the proportion of

638 for dogs 1 and 2,
796 for dogs 3 and 4,
276 for dog 5,
525 for dog 6.

Dogs 5 and 6 were receiving rather less milk per kilo. of body-weight than dogs 1–4.

Taking the quotient $\frac{\text{increase of weight}}{\text{daily food}}$ he found the value to be

·62 for dogs 1 and 2,
·68 for dogs 3 and 4,
·61 for dog 5,
·62 for dog 6.

Thus there was a better utilisation of the boiled cows' milk than of the raw.

Keller ([39]) (1904) fed two young dogs upon sterilised and boiled cows' milk respectively and found no difference between the two dogs even after three months.

Brüning ([10]) (1904) carried out two sets of experiments upon dogs.

In the first series he had six puppies (hounds) of which two were left at the breast, one was fed upon raw cows' milk and another upon boiled ; the two remaining puppies received raw and boiled goats' milk respectively. The puppy fed upon raw cows' milk died on the fourth day of the experiment of inhalation pneumonia, another example of the drawback of an insufficient number of animals in an experimental series.

The breast-fed puppies did incomparably better than any of the others. Then came the one fed upon boiled cows' milk, and then those fed upon boiled and raw goats' milk respectively.

The average gain for the breast-fed puppies was 113–121 grammes per day ; for the boiled cows' milk puppy 48·2 grammes per day ; for the boiled goats' milk puppy 45·7 grammes per day ; and for the raw goats' milk puppy 38·4 grammes per day.

In the second series four puppies were taken from birth. Two were fed upon the breast, the third on raw, and the fourth on boiled, cows' milk.

Here again the breast-fed puppies did incomparably better than the others.

The experiment lasted 75 days, and during this time—

Puppy 1 on the breast had increased in weight from 165 to 2,864 grammes ;

Puppy 2 on the breast had increased in weight from 205 to 2,215 grammes ;

Puppy 3 on raw cows' milk increased in weight from 299 to 1,105 grammes ;

Puppy 4 on boiled cows' milk increased in weight from 238 to 1,785 grammes.

Puppy 3 had the breast for six days and weighed 299 grammes when the raw milk was started. The figures for the increase give 2,699, 2,010, 806 and 1,547 respectively. The puppy fed upon raw cows' milk showed what appeared to be evidence of rickets and was chloroformed and examined post-mortem. No evidence of rickets could, however, be found either macro- or microscopically.

The coats of the breast-fed dogs were on the whole smoother than those of the artificially-fed dogs.

Feer's " Quotient of Increase " ([26]) (which is represented by $\left(\frac{\text{increase per kilo. of body-weight}}{\text{kilos. of milk taken}}\right)$ was worked out for the artificially-

fed dogs of this series, and was found to be 118 for the dog fed upon raw cows' milk, and 119 for the dog fed upon boiled cows' milk.

In both the series all the surviving animals developed into very good dogs.

It appears, therefore, that cows' milk can act as a substitute for mothers' milk in dogs, and that the dogs thrive better if the milk is given boiled.

The breast-fed dogs were, however, greatly superior to the artificially-fed ones.

Moro ([48]) (1907) showed that dogs fed upon human milk remained alive but were in a very miserable condition, whereas dogs upon cows' milk did extremely well. These results taken in conjunction with the results obtained by the same observer on rabbits, show that in deducing results from experiments it is very important to use a species of animal whose milk is suitable for the other species whose growth is being investigated. The milk of one species of mammal is by no means always suitable for the young of another species. This appears again in the experiments upon kittens which will be described immediately.

Experiments on kittens.

Chamouin ([18]) (1892) took kittens 30–40 days old, and fed them on raw and boiled cows' milk, three kittens on each kind of milk. There was also a control breast-fed kitten. The experiment lasted 12 days. The control kitten put on 560 grammes in weight. The kittens fed on raw cows' milk put on 172 grammes, and the kittens fed upon boiled cows' milk put on 349 grammes each. It seems, however, that the artificially-fed kittens were not in a good state of health, and that not improbably had the experiment lasted much longer the artificially-fed kittens would have died.

From some work carried out by Grünbaum for the Local Government Board, (referred to in the Annual Report of the Medical Officer to the Board for 1906) it seems fairly evident that cows' milk is not a suitable substitute for mothers' milk for kittens, until they have reached an age when mothers' milk is no longer necessary.

Vincent ([66]) (1911) has carried out some experiments upon kittens. These experiments as such do not come within the scope of this report ; but since he deduces from them that boiled milk is harmful for babies, brief mention must be made of them.

The kittens taken were of the age of two months, and the feeding was carried out by the animal attendant. Milk was brought from the Infants' Hospital and after the milk had been raised to 200°F. it was incubated for 24 hours at 85°F. In most of the series the milk, after heating, was inoculated with special organisms, the action of which it was desired to study.

All the kittens fed upon these foods died. It is clear that no kitten was fed upon boiled milk as ordinarily meant by the term, since even where there had been no inoculation of the milk, it was incubated for 24 hours before administration and therefore not comparable with milk which, in accordance with usual practice, is boiled and used very shortly afterwards.

None of the experiments on kittens seem to have given results upon which any reasonable deductions can be based in regard to the

relative nutritive value of raw and boiled cows' milk as a food for either infants or kittens.

Experiments on pigs.

Brüning ([11]) carried out experiments upon young pigs.

The litter used consisted of seven pigs. Pigs A, B, C, were left with their mother, but were only allowed to feed at stated intervals, and were weighed before and after each feed, so that the total quantity of milk taken was known. Pigs D and E were fed upon boiled cows' milk, and pigs F and G upon raw milk.

The initial weights of the pigs varied from 912–1,365 grammes. The supply of mothers' milk was poor, and the breast-fed pigs obtained a much smaller quantity of milk than the artificially-fed pigs. All ate well and put on weight well.

No appreciable difference could be detected between the different pigs D and E, and F, and G, but the artificially-fed pigs doubled their weight rather sooner than the breast-fed ones; possibly owing to the shortage of food-supply in the latter case.

Feer's quotient (increase per kilo of body-weight ÷ kilos of milk taken) gave a value of 165 for the breast-fed pigs, of 65 for the pigs fed upon boiled cows' milk, and of 60 for those fed upon raw cows' milk.

Mothers' milk is therefore very much better utilised by pigs than cows' milk, and boiled cows' milk rather better than raw.

Bamberg ([1]) (1910), realising that in all the experiments which had been carried out so far ordinary impure market milk had been used, undertook some experiments upon pigs, in which he used the purest milk obtainable in Berlin. The bacterial content of the milk was taken and the milk was found to be almost germ-free throughout the experiment.

The milk was obtained from the Viktoria Park Dairy.

A litter of eight pigs was taken immediately after birth.

Of these pigs—

A and B were fed upon raw cows' milk from the Viktoria Park Dairy.

C and D were fed upon boiled cows' milk from the Viktoria Park Dairy.

E was fed upon raw cows' milk (market milk).

F was fed upon boiled cows' milk (market milk).

G and H were fed upon the breast.

Pigs G and H doubled their weight on the 14th day.
„ A „ B „ „ „ „ 17th day.
Pig F doubled its weight on the 19th day.
„ C „ „ „ „ 20th day.
„ D „ „ „ „ 23rd day.
„ E „ „ „ „ 32nd day.

Pigs C and D did not seem quite so happy as A and B.

As regards weight therefore the pigs fed upon raw germ-free milk did rather better than those fed upon the same milk boiled. But the pig fed upon boiled market milk did very considerably better than the one fed upon raw market milk.

Feer's quotient was worked out for the artificially-fed pigs and the following values were obtained :—

	Pig A.	Pig B.	Pig C.	Pig D.	Pig E.	Pig F.
1st Week ...	85·5	68·1	54·0	49·2	19·1	55·7
2nd „ ...	61·2	68·0	60·0	41·2	29·5	30·8
3rd „ ...	55·2	30·1	26·5	29·1	47·0	21·4
4th „ ...	37·8	21·8	18·6	22·9	38·4	15·8
5th „ ...	22·1	16·0	14·1	19·1	20·7	9·3
6th „ ...	16·6	9·9	8·3	12·7	13·8	9·2
7th „ ...	13·2	7·9	6·0	8·8	7·6	5·1

As a whole therefore pigs A and B utilised their food rather better than pigs C and D. But pig F utilised its food better than pig E. That is raw germ-free milk seems to be better utilised than boiled, but boiled market milk appears to give better results than raw.

After seven weeks the pigs were returned to their owner, who reported later on that the artificially-fed pigs were all inferior to the breast-fed pigs, but that no difference could be detected between the different artificially-fed pigs.

Experiments on goats.

Brüning ([9, 11]) carried out two sets of experiments on goats, which are however, really supplementary the one to the other, and can be taken together. Each litter had consisted of three kids. These were fed as follows :—

First Litter—
- Kid 1. Breast-fed.
- Kid 2. Boiled mothers' milk.
- Kid 3. Boiled cows' milk.

Second Litter—
- Kid 4. Breast-fed.
- Kid 5. Breast twice a day and other feeds raw cows' milk.
- Kid 6. Raw cows' milk.

Kid 1. Doubled its weight on the 15th day. The value for Feer's quotient was 50·2.

Kid 4. Doubled its weight on the 16th day. The value for Feer's quotient was 53·1.

Kid 2. Doubled its weight on the 22nd day. The value for Feer's quotient was 28·4.

Kid 5. Doubled its weight on the 22nd day. The value for Feer's quotient was 25·0.

Kid 3. Doubled its weight on the 20th day. The value for Feer's quotient was 24·0.

Kid 6. Doubled its weight on the 25th day. The value for Feer's quotient was 21·0.

The initial weights of the animals were very different, so that some of them had put on considerably more weight than the others. Feer's quotient shows the nutritional value of the food, although it does not show the caloric value of the food taken.

These experiments bring out the great superiority of mothers' milk over that of cows' milk as a food for kids. They also show slight superiority of boiled cows' milk over raw.

Brückler ([8]) (1907) carried out an experiment on goats on identical lines to those of Brüning. Two litters were used, and two goats, for each method of feeding. The milk given was collected with all possible precautions, and was as far as possible germ-free. Brückler obtained a rather more rapid increase in weight with the raw cows' milk than Brüning did, but Feer's quotient was higher with the boiled cows' milk than with the raw.

Goats seem therefore to do fairly well on cows' milk, but the results are very inferior to those obtained with mothers' milk.

If cows' milk be given there is a slight advantage in giving it boiled.

Summary of results of Experiments given in Part II.

Summarising the results of preceding pages very briefly it can be inferred :—

(1) That there is no evidence to show that boiled cows' milk is markedly inferior to raw cows' milk, as a food for young calves, at any rate after the first 2 days of life. (Cp. Bang.)

(2) That the salt content is of great importance. (Cp. Hittcher and Gerlach.)

(3) That, if young animals are fed upon the milk of a suitable foreign species, they appear to thrive somewhat better if the milk is given boiled, than if given raw, the only exception being in the case of germ-free milk. (Cp. Bamberg.)

(4) That in those cases where the health of the animals was inquired into, after the cessation of the experiment, no difference could be detected in the animals fed by different methods of artificial feeding.

(5) All the animals fed by different methods of artificial feeding were inferior to the breast-fed animals, both at the time of the experiment, and afterwards.

Part III.—Clinical Evidence.

The amount of clinical material which is available for the purpose of this report is unfortunately rather scanty.

The only class of hospital cases which can be considered at all suitable for the investigation of the nutritive value of raw and boiled milk, are those of infants suffering from the lesser degrees of mal-nutrition. As hospitals are institutions for the reception of the sick, children in the early stages of nutritional disturbances do not as a rule gain admittance as in-patients. For this reason most of the work has been carried out upon children showing definite wasting, whilst some of them had reached the later stages of atrophy.

It is impossible to say how far the metabolism of such children is directly comparable to that of healthy children, but it is probable that any difference in the relative digestibility and nutritive value of the food given, would be more pronounced in the case of a sick than of a healthy child.

Any nutritional difference which might exist between raw and boiled milk might therefore reasonably be expected to be more pronounced in the case of clinical evidence than of the experimental evidence just studied. It will be seen, however, that different observers are not agreed upon the relative value of raw and boiled milk in the treatment of atrophic children.

It is usually difficult in hospital practice to keep the children under observation for a sufficiently long period to study to the full the effects of the observations made in the hospital. As soon as the children are considered to have recovered they are sent home and are lost for the purposes of the research. Thus, their history is only known at the time of the acute disturbance.

The data given in papers on clinical research are often insufficient and control experiments in most cases are wanting.

The details of the source and preparation of the milk given are frequently entirely omitted, nor is it by any means always clear whether the milk spoken of as "sterilised" is really boiled or sterilised, or *vice versâ*. For this reason some of the cases fed upon "sterilised" milk will be dealt with although literally outside the subject of "boiled" milk.

The quantity and quality of the milk used is frequently neglected, except in the case of metabolism experiments, where it is evidently essential that it should be known. The estimation of Feer's quotient of growth, which is justly considered of great value in the experimental evidence on animals, (see Part II) receives scant, if any, attention.

A serious source of error lies in the small number of children which it is possible to have under observation in hospital, whose condition is such as to render them comparable for experimental purposes.

Hence much of the work done must be taken as dealing rather with isolated cases, than as proving any general facts in regard to the relative nutritive values of raw and boiled milk, as a food for infants. The literature contains a large number of lectures, papers, and discussions upon the question now under consideration, but only those containing definite facts have been dealt with here. There is no doubt that many members of the medical profession both in this country and abroad are strong advocates of raw milk in private practice. I have not however met anyone who was able to give any definite data showing the superiority of raw over boiled milk as a food for infants.

In private practice where raw milk is ordered, the medical adviser selects a dairy of known reputation, and special precautions are often taken in the care of the milk. It is therefore intrinsically a better milk than that which is commonly employed when boiled milk is prescribed to the poorer classes of the population. A higher price is paid for the milk, in order to have a superior milk which can be given raw.

It is impossible to avoid the impression that many of the opinions formed by medical men in private practice, are based upon a comparison between the well-to-do baby fed upon expensive raw milk,

and under proportionately favourable conditions, and the baby of the poorer classes, fed upon inferior boiled milk, and under greatly inferior social conditions. Such comparisons even if based—as they are in some cases—upon some degree of knowledge of the progress of the baby's weight are valueless. It is only by feeding babies upon raw and boiled milk of the same quality, that any reliable evidence can be obtained.

Such evidence as is available will now be considered in chronological order. The clinical evidence—like the experimental—can be divided into the two main divisions :—

(1) Those fed on raw and boiled milk of the same species, and

(2) Those fed on raw and boiled milk of a foreign species,

and will be considered under these two headings.

Div. I.—Infants fed upon boiled milk of the same species.

Under this heading come infants which have been fed upon boiled mother's milk, or boiled human milk, that is upon milk of a woman not their mother.

In this country where wet-nursing is rarely if ever practised, cases in which it might be advisable to express and boil human milk, only occur in very exceptional circumstances, and do not ordinarily come into clinical consideration. On the Continent, however, where wet-nursing is extremely common, such cases are by no means infrequent. When syphilis in a woman is suspected but not proved, it is evidently undesirable that she should suckle any child other than her own. In these circumstances the milk may be expressed and boiled, and the child fed with human milk from a bottle without fear of infection.

This has been done in many cases, and the subject has also been studied experimentally, in a few others. Opinions are not quite agreed as to the results.

Moro ([49]) (1902) describes two cases of weakly children who received first of all the breast, and were then fed upon the expressed milk, which had been boiled for 10 minutes. The children showed a markedly inferior gain in weight upon the boiled human milk, to that which they exhibited upon the breast milk.

The average gain in weight noted was as follows.—

In case I :—

In 14 days on the breast the average gain was 26½ grammes per day.

In 8 days on the bottle with raw human milk the average gain was 37 grammes per day.

In 10 days on boiled human milk the figure was 9·9 grammes per day.

In case II :—

In 7 days the average gain on the breast was 14 grammes per day.

In 5 days on raw human milk in a bottle it was 20 grammes per day.

In 7 days on boiled human milk it was 9 grammes per day.

It would be unwise to base any assertions upon two experiments, but as far as the experiments go, it would appear that some of the

value of the human milk is lost by boiling. It is curious that both children showed a greatly increased average gain per day, when fed upon the human milk in a bottle, and this rather suggests that they were getting more actual food in the shape of a larger quantity of milk. It might be that different results would have been obtained if the milk had not been boiled for as long a time as 10 minutes. Moro attributes the effect produced to a loss of the so-called "protective substances" of the milk.

L. F. Meyer ([46]) (1906) in the course of his "Exchange" experiments where three children were fed upon human whey and the protein of cows' milk, and then upon cows' milk and the protein of human milk, found that if the human whey was boiled the good results obtained with the first mode of feeding were greatly reduced. As, however, the experiment was only carried out over a very few days, and was an isolated one, it cannot be taken as proving that substances necessary for health are lost by the boiling of milk.

It would appear also that Meyer himself does not lay much stress upon this experiment since in his book (1910) in conjunction with Langstein ([42]) he says "clinical observation could not show any advantage of raw cows' milk over boiled, and recent experiments have also shown that the boiling of human milk does not cause any deterioration of its nutritive value."

Potpeschnig ([55]) (1907) carried out some work with a view to ascertaining whether these same hypothetical substances having a protective function were injured by heating to 60°C., this being the temperature to which v. Behring considered that milk might safely be heated, without undergoing any loss of nutritive value.

Two children, both premature, were fed at the breast of a wet-nurse until it was evident that they were doing well, and the weight-curve showed a daily satisfactory increase. This was for a period of three days. The children then received the milk after it had been expressed and kept cool: all aseptic precautions being taken. Both children showed a transient loss of weight, but in a few days the weight curve again began to rise, and showed a steady increase. This period lasted five days.

The expressed milk was now heated to 60°C. for ½ hour, and was then stored in the cold room for use as required. The period of this form of feeding lasted 17 days, and the weight-curve showed a steady rise throughout the entire period, nor could a disturbance of any kind be detected. After this, the wet-nurses being no longer available, the children received boiled cows' milk, and the weight-curves continued to rise just as steadily as with the boiled human milk.

The author considers that these children are no criterion since they did as well upon boiled cows' milk, as upon human milk, and thus he says were evidently capable of manufacturing their own "protective substances."

E. Müller ([50]) (1908) carried out a very interesting experiment upon a child under his care. This baby was premature and weakly and was 25 days old when it came under his treatment. The child was first of all put upon the breast of a wet nurse, and made very little

progress, the average gain in weight being 12 grammes per day. The baby was therefore put upon a diet of raw human whey and raw cows' fat and casein ; this feeding was continued for five days, during which time the child gained weight at the rate of 44 grammes per day. The author considered this increased gain in weight due to the increase of protein material in the food. Next it received cows' whey and human fat and casein both raw, for 14 days, but the results obtained were not similar throughout the period. For the first five days the child made good progress and put on weight at the rate of 33 grammes per day, but during the last nine days it only gained 30 grammes in the whole period. There was also a tendency to diarrhœa. It was then put back upon human whey and cows' casein and fat, and again made good progress, gaining 17 grammes per day for three days. The human whey was now boiled and mixed with the cows' casein and fat, and the child gained in weight at the rate of 15 grammes per day for 33 days. It would seem therefore that no harm was done to the nutritive properties of the human whey by the boiling of it.

Muller points out that the upholders of the theory of "protective substances" in milk, all agree that these are present in the whey ; hence this case in which he fed a weakly child with success upon boiled whey (in which presumably these same substances, if present, were destroyed) is of considerable interest.

Finkelstein ([28]) mentions that he fed six babies upon boiled mother's milk, and found that they did not do so well as upon the raw human milk, and concludes therefore that the milk of the same species loses some of its value by boiling ; in contradistinction (as will be seen below, p. 22), to that of a foreign species. He does not give any data upon this point.

The most numerous cases I have been able to discover are those of Prof. Thiemich of Magdeburg. They are unfortunately as yet unpublished, although the data are available, but Prof. Thiemich has been so kind as to give permission to me to quote his experiences for the purpose of this report. He has furnished me with a short report of his results, as follows :—"In my wards the milk of all the "new wet-nurses is given boiled only, until Wasserman's and Stern's "reactions* have been carried out."

"If it happens, as it frequently does, that one or other of the "reactions is positive or doubtful, and there is no detectable evidence "of specific trouble in either mother or child, I sometimes keep the "wet-nurse for many months, and during the whole of this period her "milk is only given boiled. I may add that in the case of an infant "living with its parents which requires a wet-nurse or human milk "for "allaitement mixte" it is only in very exceptional cases that I "allow actual suckling. Otherwise only expressed and boiled milk, "human milk, is given by the bottle in suitable quantities. Similarly "the milk of a feverish wet-nurse is boiled, not because of the risk of "the direct passage of any organisms in the milk, but because of the "possibility of outside contamination of the milk.

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* Stern's reaction is a modification of Wassermann's and apparently sometimes clears up a doubtful diagnosis obtained by Wassermann's method.

"On this system I have now seen a great number of children "improve just as well upon boiled human milk, as happens with raw "human milk.

"In a smaller number of cases raw and boiled human milk have "been given alternately and systematically for various periods of "days and weeks with the same result, namely that no difference "could be detected."

It is much to be hoped that Professor Thiemich will shortly publish his data in full, so that the actual figures on this very interesting point may be available.

The data available are evidently insufficient to enable any definite conclusion to be drawn in regard to the comparative nutritive values of raw and boiled human milk. It will be realised, however, that this is an entirely different problem from that of the comparative nutritive values of the raw and boiled milk of a foreign species. The great variety in chemical composition in the milks of different species, leads to the assumption that the milk of each is adapted especially for the needs of that particular organism. It is conceivable therefore that in such a complex and presumably nicely-adjusted food as milk, the slight changes produced by boiling might have a more important effect upon the nutrition of the young animal of the same species, than would be produced by the corresponding changes induced in the less-well adjusted milk of a foreign species. From the evidence above given there can be no doubt that many babies thrive well upon boiled human milk, and hence it must be supposed either that the changes produced by boiling are insignificant, or that the milk is not so finely adjusted to the needs of the particular species as to lose by boiling any appreciable portion of its nutritive value. The importance of salts in the feeding of calves upon raw and boiled cows' milk has already been dwelt upon (pp. 4, *et seq.*).

Div. II.—Clinical Evidence in regard to Infants fed upon Raw and Boiled Milk of a Foreign Species.

As has been already pointed out, most of the papers which have been published deal with children in different stages of atrophy. In this report only such evidence as treats of the feeding of these with raw and boiled milk has been considered, all other treatment of atrophic infants being neglected.

In 1891 Uhlig ([62]) quoted 39 cases of children suffering from various degrees of mal-nutrition, who all did well on sterilised milk. No control cases were taken.

In the same year Leeds and Davis ([22]) published an account of the results of feeding sick children—all apparently suffering from diarrhœa—on sterilised milk. The results were not good, some of the children dying from apparent starvation. No improvement followed the peptonising of the milk, although Fowler's solution and cod liver oil helped. Marked improvement occurred in such children as received a few breast-feeds in the day, together with the sterilised milk. No controls seem to have been carried out with raw or pasteurised milk.

Much stress cannot be laid upon these results, since there were no controls, although Davis states that he has seen children who were not improving on sterilised milk do well upon raw. The milk in these cases of Davis's above quoted was sterilised for half an hour.

Variot ([63]) (1898) at a meeting in Paris quoted 30 cases of atrophic children who had attended his consultation at Belleville, and who had all done very well when fed upon sterilised milk. He gave no control cases.

Palmer ([52]) (1900) described the satisfactory results which he had obtained in America with raw milk, and advocated its use. He gives no control cases fed upon boiled milk, and, moreover, had the great advantage of the large ice-supply of American cities. No actual data are given.

Monrad ([47]) (1902) published six cases of atrophic and dyspeptic children who had improved when fed upon raw milk. He considers that only certain cases need raw milk. No controls fed upon boiled milk are given.

Czerny ([21]) (1902) at the Breslauer Klinik fed atrophic children upon both raw and boiled goats' milk, the goats being kept upon the premises. He was unable to detect any appreciable difference between the children fed upon raw and boiled goats' milk; both sets were very constipated, those fed upon raw milk rather more so than those fed upon boiled milk. The improvement in all cases was very inferior to that which usually occurs when similar cases receive mother's milk.

Halipré ([36]) (1904) quotes the case of a child whose weight was increasing at the rate of 7 grammes per day while fed upon sterilized milk. When given raw milk the increase rose to a rate of 30 grammes per day. He states that he has seen other similar cases. The degree of sterilization of the milk is not given.

Hohlfield ([38]) (1905) published eight cases of children suffering from various stages of mal-nutrition who were fed for the most part upon raw milk, some however received raw milk alternately with boiled milk over periods of about one month. All the children were ill, some of them severely. Three had only raw milk, two vomited boiled milk, and another put on more weight on raw milk than on boiled milk. The remaining two were twins, of whom the sicklier child was put upon raw milk, and the healthier one had boiled milk. The sicklier one did better than the healthier one.

These data certainly seem to show that there are cases of sick children where raw milk gives better results than boiled milk; at the same time the evidence already given shows that many children who are suffering from mal-nutrition do extremely well upon boiled milk. It would not appear to be justifiable to draw conclusions in regard to the relative nutritive properties of raw and boiled milk in the treatment of healthy babies, as a result of these experiments of Hohlfield's, where only four babies were given boiled milk, and of those, two had an apparent idiosyncrasy against boiled milk and vomited it after administration.

Vincent ([65]) (1906) has published 20 cases of markedly severe malnutrition in infants, which were fed upon raw milk and did very well. These cases were fed upon the percentage method of feeding, under constant supervision, and often of change of the percentage of ingredients. No case was fed upon boiled milk of a similar percentage mixture.

The work of most value is that of Finkelstein ([28]) (1907), who carried out prolonged experiments upon both healthy and atrophic children, as well as upon those suffering from acute disturbances. As far as possible the same number of children were fed upon raw and boiled milk in each of these groups. The milk used was from the best dairy in Berlin, and was of excellent quality; the same milk was used for administering raw and for boiling.

The results are best seen by reproducing Finkelstein's table of results.

Group I. (A) Healthy children, that is children with no apparent signs of disease; under eight weeks of age, and having an average weight of 3,600 grammes.

—	Raw milk.	Boiled milk.
Number of children	29	19
Average number of days of observation	34	27
Good result—good progress, no disturbance	10 = 34·4 per cent.	10 = 52·6 per cent.
Daily increase	15·5 grammes.	19·8 grammes.
Fair result—progress not so good, no disturbance ...	7 = 24·1 per cent.	2 = 10·5 per cent.
Daily increase	7·6 grammes.	8·0 grammes.
Bad result—loss of weight, or appearance of acute disturbance.	12 = 41·5 per cent	7 = 37 per cent.

(B) Twelve children were fed periodically with raw and boiled milk. The results were—

—	Average length of feeding,		Daily increase.	
	Raw milk.	Boiled milk.	Raw milk.	Boiled milk.
	days.	days.	grammes.	grammes.
Raw and boiled milk equally good 3 = 25 per cent.	33	17	16·3	14·7
Raw and boiled milk equally bad 4 = 33 per cent.	32	22	— 5·1	—11·0
Raw milk better than boiled 3 = 25 per cent.	27	20	13·5	—10·0
Boiled milk better than raw 2 = 16 per cent.	25	19	3·5	15·5

Group II.—Atrophic children, older than Group I., markedly below weight, but without other symptoms of disease. Raw and boiled milk given periodically.

—	Average length of feeding.		Daily increase.	
	Raw milk.	Boiled milk.	Raw milk.	Boiled milk.
	days.	days.	grammes.	grammes.
Raw and boiled milk equally good, two cases.	37	36	20	16
Raw and boiled milk equally bad, one case.	28	33	5	1

Group III.—(A) Children with digestive disturbances, showing strong local and, usually, general symptoms. The quantity, &c., of the food was the same in both cases.

—	Raw milk.	Boiled milk.
Number of children	25	16
Average length of observation in days ...	38	26
Improved and did equally well	15=60 per cent.	16=68·8 per cent.
Did not improve	10=40 per cent.	5=31·2 per cent.

(B) Nine children were fed periodically with raw and boiled milk.

—	Average length of feeding.		Daily increase.	
	Raw milk.	Boiled milk.	Raw milk.	Boiled milk.
	days.	days.	grammes.	grammes.
Improved equally well with raw and boiled milk, 4=44 per cent.	33	22	19	19·3

No improvement with either raw or boiled milk, 3=33 per cent.
Improved on raw milk, after failure on boiled milk, 1=11 per cent.
Improved on boiled milk, after failure on raw milk, 1=11 per cent.

Finkelstein concludes that "no definite distinction between the "results obtained by feeding upon raw and boiled milk respectively, "could be detected." If these figures of Finkelstein's are examined a little further, it is seen that in Group I. (A) there is a balance in favour of the boiled milk, whereas in the other groups there is a balance which is slightly in favour of the raw milk.

Finkelstein also quotes three cases of anæmia with splenomegaly, who showed no improvement with very prolonged feeding upon raw milk, but which subsequently recovered on boiled milk.

Plantenga ([54]) (1910) treated children with digestive troubles with both raw and boiled milk, and from a study of the weight-curves

was unable to find any evidence of the superiority of the one over the other, or *vice versâ*.

Reviewing the clinical evidence as a whole, it seems impossible to draw any other conclusion than the following :—

If healthy or not markedly atrophic children are considered, no great difference can be detected between the nutritive values of raw and boiled milk, given always that the quality of the milk is the same.

If markedly atrophic or sick children are considered, there appears to be a good deal of idiosyncrasy, some doing well only upon the one form of food, and some only upon the other. The value of much of the clinical work on this subject is very much reduced by the absence of control cases. In this respect the earlier work is especially deficient; as also in regard to the details of the milk given.

Metabolism Experiments.—A considerable number of metabolism experiments have been carried out upon infants with a view to ascertaining the difference in the values of raw and boiled milk respectively. These, however, are somewhat beyond the scope of this report, since if pushed to their conclusion these experiments really lead towards the discovery of those constituents of the milk, if any, which are injured by boiling. It is impossible in any one experiment to estimate the metabolism of all the constituents of the milk, and one or two must therefore be selected. Hence by these experiments information is gained as to the nutritive value of different constituents of raw and boiled milk, and not of raw and boiled milk as a whole, which last alone is being dealt with in this report.

It is, however, very usual to regard nitrogenous metabolism as giving considerable indication of the general state of health of the body, and it may therefore be of advantage to deal briefly with a few of the experiments which have been carried out in this direction.

Bendix ([4]) (1894) fed children of from 1½–2 years old upon boiled and sterilised milk during alternate weeks. The children also received chocolate, apple jelly and bread. The only difference which could be detected in the metabolism of the infants was a decrease in the nitrogen-absorption of ·4 per cent. with sterilised milk, and an increase in the fat absorption.

It may be noted that the children were no longer infants.

Lange ([43]) (1895) worked upon dyspeptic infants, and found that the dyspeptic infant passes a larger amount of fæces, and that the total content of nitrogen although absolutely greater, gives a lower percentage, than in healthy babies.

He used nine artificially-fed babies, and one breast-fed baby, the former being fed upon modified cows' milk, sterilised. He found that the assimilation of nitrogen with the cow's milk was almost as good as with mothers' milk, being 95·4 per cent. as against 97·57 per cent. of the nitrogen taken in. The experiments were conducted over one or two days only, and it is regrettable that only one breast-fed baby was taken.

Koplik ([40]) (1895) fed four children upon different varieties of milk:—

1st child, 3 months old, was fed upon the breast and sterilised milk for 6 days.
2nd child, 3 months old, received sterilised milk for 6 days.
3rd child, 3 months old, received—
(1) Pasteurised milk (70°C.) for 7 days.
(2) Sterilised milk (100°C.) for 7 days.
(3) Raw milk for 7 days.
4th child, 5 months old, received—
(1) Boiled milk for 3 days.
(2) Sterilised milk for 7 days.

He found great variations in the daily amounts of nitrogen in the fæces from day to day, in all the methods of feeding, and concluded that in this respect no difference could be detected between the different methods of feeding with cows' milk.

Here again therefore it seems impossible to detect any difference between the nutritive values of raw and boiled cows' milk in the feeding of infants.

The alleged production of Rickets and Infantile Scurvy by boiled milk.—It will be of advantage to examine briefly the main objections which have been raised against the use of boiled milk as opposed to raw.

These consist in the alleged production of rickets aud infantile scurvy, as a result of the prolonged use of boiled or sterilised milk.

It would be impossible in this report to discuss this subject at length, but some points can be dealt with.

Many thousands of children are fed every year both in this country and on the Continent, on pasteurised, boiled, and sterilised milk. No records are available of a very great number of these cases, but a vast mass of material has gradually been accumulating at the large Infant Consultations which have now been in existence for a considerable number of years in many of the great cities of Europe.

So far as I can ascertain there is no consultation of any size in Europe where the infants attending this institution are consistently fed upon raw milk. They are fed upon pasteurised, boiled or sterilised milk. It may be again pointed out, that owing to inaccuracy of nomenclature milk is often described as "pasteurised" which is really boiled, or just brought up to boiling point of water, and milk which is called "sterilised" is really only "boiled."

If, however, boiled or sterilised milk really produce either rickets or Barlow's disease (infantile scurvy) then these troubles certainly ought to be prevalent among the children attending the consultations where these forms of diet are used. A large number of reports of these consultations can now be obtained giving accounts of the health of the children, who are seen at frequent intervals. A few of these reports only need be considered. Thus in 1904 Mons. Variot ([64]) issued the report of his consultation at Belleville, near Paris, where the children were fed on sterilised milk (heated to 108°C.).

In 3,000 cases included in this report no case of Barlow's disease is recorded.

A few cases which had been either over-fed or had received farinaceous food while still too young developed rickets, but not Barlow's disease, and all the other children did very well.

A similar testimony is borne by Mons. Bresset ([15]), the presiding physician at one of the consultations in Paris. Among over 2,000 cases fed on sterilised milk, no case suspicious of Barlow's disease was seen. Rickets was rare, and seems altogether to be far from common among the Parisian children.

Budin ("The Nursling," Chap. 9) says: "As for the so-called "'infantile scurvy,' which is alleged to follow the use of sterilised "milk, I have heard a very great deal about it during the last few "years, but I am still looking for my first case."

In Berlin thousands of children attend the municipal consultations and Barlow's disease is rare. (Private information from Dr. Ballin.) Rickets is a very common disease in Berlin, but it will be seen in Part IV. (p. 35) that this can hardly be attributed to the feeding upon boiled milk.

As regards the question of the occurrence of Barlow's disease and rickets, Escherich ([25]) says: "Infantile scurvy (Barlow's disease) "I have not once seen among all the many thousands of children "fed artificially and with sterilised milk, which passed through my "hands in München and Graz." And later "As regards the much "disputed question of rickets, in my experience it is hardly less "frequent in breast-fed babies than in bottle-fed ones: the worst "degrees of rickets are, however, only met with in the latter class."

It would appear therefore not to be correct to assert that rickets and Barlow's disease are caused by the administration of either boiled or sterilised milk, as such, although when Barlow's disease occurs the infants have often been fed upon sterilised milk. They have also often had an undue amount of farinaceous food.

The cases published by Cheadle ([19]) in 1878 had all been fed upon farinaceous food, and if the literature be studied it will be found that these are by no means isolated instances.

La Fetra ([27]) and others quote cases of Barlow's disease occurring in breast-fed babies, and in children who had been fed upon various kinds of food. In order to account for its appearance in the breast-fed babies, the disease was attributed to the state of health of the mother.

Medical literature contains no lack of clinical reports upon cases of this disorder, and the almost dramatic manner in which a cure can be effected probably tends to give infantile scurvy a more prominent place than is usually accorded to a disease which is far from common, and for which definite and satisfactory lines of treatment are known.

Although Barlow's disease is not confined to children fed upon one class of food, at the same time the great majority of patients with this disease do appear to have been fed upon milk which had been subjected to prolonged boiling or sterilising, or to milk which had been manipulated to an unusual extent.

In the recent literature Lust ([44]) quotes six cases seen by him within a short time in private practice, which were suffering from

infantile scurvy. All these cases had been fed either upon sterilised milk, or upon Backhaus milk (a somewhat elaborately prepared milk) and he considered that there was evidence that it was associated with over-feeding.

Many other similar cases might be quoted from the literature of the subject.

The Medical Society of Geneva recently held an inquiry into the frequency of the occurrence of Barlow's disease in Switzerland ([7]). Papers of inquiry were sent to the medical men of the district, and 71 answers were received.

Of the 71 only five had seen cases of the disease, and only 10 cases were reported, of which six were reported from Geneva itself.

Of these 10 cases nine had been fed either upon special forms of milk or upon milk sterilised at high temperatures. The tenth child had been fed upon milk prepared in a Soxhlet apparatus.

It seems possible that the length of time which the milk is kept before consumption may be of importance. Thus, Carel ([28]) quotes the case of a child which was taken away from home with a large supply of sterilised milk, sufficient for several weeks. Apparently the child showed symptoms of Barlow's disease, which disappeared with the arrival of a fresh supply of sterilised milk. As this fresh supply became stale the symptoms reappeared and the child was brought for medical advice, and the case diagnosed as one of infantile scurvy. The relations stated that the symptoms were identical with those which had disappeared when the fresh supply of sterilised milk was given to the child.

Plantenga ([54]) has published an account of an outbreak of Barlow's disease which occurred among the children of his consultation. During one year the milk which was given out at his consultation was pasteurised over night by heating at 70° C. for ½ hour. The milk, therefore, although not boiled was yet subjected to prolonged heating. In the morning this milk was further heated, being boiled for five minutes in a Soxhlet's apparatus. In that year 23 cases of Barlow's disease developed among the babies of the consultation, out of a total number of 200.

As a result of this outbreak the routine of the milk preparation was changed, and the morning's milk was merely pasteurised without being kept. No case of Barlow's disease occurred on this form of milk. Plantenga attributed the occurrence of the trouble to the length of time the milk had been kept before it was used, and he pointed out that the value of raw milk in certain cases may arise from the fact that it is given sooner after milking.

The available clinical evidence in connection with the milk of a foreign species, cannot be said to show any marked difference in the nutritive properties of raw and boiled milk when used in the treatment of infants in health, or suffering from nutritive disturbances.

As regards "sterilised" milk or milk which has been heated over prolonged periods or at high temperatures, it appears that it also can be used with good results. At the same time it seems probable that sterilised milk which has been kept or milk which has been subjected to somewhat extensive manipulations may be one of the factors in the production of infantile scurvy. The number of cases of this disease which arise in children fed upon

sterilised milk, and other forms of milk is, however, so small in comparison to the number of infants thus fed, that it does not seem reasonable to suppose it to be the only factor concerned.

Summary of the Evidence of Part III.—The clinical evidence as to the nutritive value of boiled human milk as an infants' food is on a small scale ; but the infants who have been fed on such milk over prolonged periods (cp. Thiemich) show equally good nutrition with the breast-fed infants. A few observers working with scanty material and over a short period have arrived at a different conclusion.

There is considerable divergence in the conclusions based on experience of different observers, as to the relative nutritive value of raw and boiled cows' milk as a food for infants. Some observers claim to have obtained better results by feeding infants on raw than on boiled milk. Some have found no detectable difference between the two groups ; and others even claim an advantage in favour of boiled milk. The balance of evidence may be said not to show any decided superiority on the side of either raw or boiled cows' milk as a food for infants.

Part IV.—Method and Results of working up the Berlin Material.

The material for this research was obtained, as already mentioned (p. 4), from the Infant Consultation of the Naunyn Strasse in Berlin. This consultation is conducted by Dr. Ballin, to whom I am deeply indebted for permission to use his material.

Source of the Material.—Six years ago, infant consultations were started by the municipality of Berlin, under the auspices of a special fund, the Schmidt-Gallisch Stiftung.

Four were first started, and then another, and finally two more, thus making seven in all, in different parts of Berlin.

Each of these consultations is in charge of a medical officer who has made a special study of the diseases and ailments of children. The attendance is so large that assistants have been appointed to assist the medical officer in the discharge of his duties. The consultations are held daily, and at the Naunyn Strasse (where the material here dealt with was obtained) the average daily attendance is about 100 babies.

Each Consultation has its own staff of health visitors attached. These are women who have been thoroughly trained for work among children, and are appointed by the municipality to visit the homes of the babies who are brought up to the consultation. Their duty is to instruct the mothers in the general care and hygiene of the infant in accordance with the directions given by the medical officers at the consultation.

The clientèle of the consultation consists exclusively of the working classes. The fathers of the children who are brought up to the consultation are for the most part earning about 20–30 marks a week (see p. 41 and table VI.).

Parents whose income is over 40 marks a week are expected to pay a private doctor, and are only allowed to attend in very special cases.

The attendance at the consultation is entirely voluntary, except in a few cases where the babies are illegitimate, and are boarded out under the Poor Law authorities; here the consultation is used as a means of keeping the baby under medical supervision.

The simpler ailments of children are dealt with at the consultation, but sick children in need of in-patient treatment are referred to the hospital.

Breast-feeding is actively encouraged, and the great majority of the children are breast-fed. Small nursing-bonuses are given to the nursing mothers. (Usually about two marks a week.)

The Milk Supply to the Consultation.—Regulations to ensure the quality and purity of the milk for the babies attending the consultation were drawn up when the consultations were first started, and tenders were invited from dairies who were willing to comply with the regulations. The milk was required to be of a high standard, and was subjected to regular chemical and bacteriological examination by the municipality.

Two years ago, the town of Berlin started its own dairies outside Berlin, and all the municipal institutions are now supplied from these municipal dairies.

In these dairies 200 cows are kept which are tubercle-free, and the farm is conducted upon all the model lines of an up-to-date dairy.

The milk is examined chemically and bacteriologically, and I was informed that the fat content is never less than 3 per cent., and the bacterial count varies from 20,000 to 30,000 per c.c. The milk is thus one of great purity.

After milking, the milk is rapidly filtered, bottled, and cooled to 3–4° C., at which temperature it is kept in the cold chamber. It is sent off as soon as possible by special train to Berlin, where it is delivered in cooled vans to numerous centres (about 80) in various parts of the town, whence it is fetched by the mothers of the infants attending the consultation, who are being artificially fed.

Milk is not given out by the consultation, except in a very few cases in which for some reason a plain milk dilution is not considered suitable.

The milk is paid for in full if possible by the parents of the babies, or in part if the social conditions are poor. Each case is dealt with on its own merits on the report of the health visitor, and in some cases the milk is given free. No child is allowed to have a deficient supply of milk as a result of the poverty of its parents.

Over-feeding is avoided by the amount ordered by the medical officer being written on a separate card, which the mother has to show to the dairy when the milk is fetched. The card is valid only for a certain number of days (usually 7–10 days, according to the discretion of the medical officer of the consultation), being stamped

with the date up to which the milk may be given out by the dairy. After that date the mother must bring the baby up to the consultation in order to have the card stamped for a further period. The food of the infant and the milk of the municipality are thus kept under control.

The milk is ordered to be diluted on much the same lines as are followed in this country. The preparation of the milk in the home is under the care of the health visitor who personally instructs the mother in this important matter. The milk is fetched from the dairy, is cooled, and is directed to be brought to the boil, and to be allowed to froth up twice. It is then at once covered, and placed in a vessel of cold water. In hot weather the water is directed to be changed frequently. Thus every care is taken of the food for the artificially-fed baby.

The Notes taken at the Consultation.—Full and careful notes are taken at the Consultation, and entered on special sheets. The notes show the date of the child's birth, the date of its first attendance at the consultation, the feeding of the infant before its first attendance, the health of the parents, the number of children in the family, the wages and the general social condition of the family, the legitimacy or illegitimacy of the infant, and any other point which may require noting.

During the attendance of the infant the dates of its attendance, the weight at each attendance, the directions as to feeding, and the medical notes as to the child's health are all entered upon these sheets. In addition the remarks of the health visitors as to the general condition of the home, the baby, and the milk are entered after each visit. The visits are made at frequent intervals.

The records are thus very complete, and many thousands of such charts are stored at the consultation in the Naunyn Strasse.

In copying the data required from these consultation sheets, the following points were taken—

(1) The date of the child's birth.
(2) The date of its first attendance at the consultation.
(3) The legitimacy or otherwise of its birth. (Nearly all were legitimate.)
(4) The wages of the father.
(5) The number of children in the family.
(6) The weight at each attendance.
(7) The date of each attendance.
(8) The medical notes.

The last three points were tabulated in columns in the following manner, the day of age of the children being worked out afterwards and carefully checked—

Date.	*Day of Age.*	*Weight.*	*Remarks.*
10th August, 1908.	20	3,300 grammes.	Breast, six times a day.
20th August, 1908.	30	3,500 „	Bronchitis.

and so on.

Selection of Material.—It will be remembered that the object of the investigation was to compare the nutrition, as measured by weight, of infants fed on the breast and on boiled cows' milk. The selection of the material presented several points of difficulty. It was necessary to deal with two main series of infants :—

(1) Healthy babies of the average artisan class, fed upon milk in various forms, in order to have a control consisting of the average baby.

(2) Healthy babies of the same class but fed only upon boiled cows' milk, in order to study the difference, if any, produced upon the average baby of the class by feeding it exclusively upon boiled milk, as compared with the infant of class (1).

In considering the babies of this first class, it appeared that far the larger portion were fed upon the breast, and that all the others were fed upon boiled cows' milk. There were a very few cases of mixed feeding upon the breast and on boiled milk, lasting over a few weeks.

This was of course foreseen, since the material which was to be used was that of an infant consultation where the babies were if possible fed upon the breast, and failing that upon boiled milk.

Hence if the babies attending the consultation had been taken seriatim, regardless of the variety of feeding they were receiving, and had been utilised for preparing control statistics under the first head given above, the results would have been complicated by the presence of a considerable number of babies of the second class, which was required to be a class by itself. It was decided to exclude from the control series all babies who had received less than four months breast feeding, taking into consideration further points described below.

Further, in order to eliminate the effects of temperature it was considered advisable as far as possible to take the babies of both classes from the same years. They were all taken from the years 1907–08, and 1908–09, and about half the cases taken came from each of these years.

The most serious difficulty in the selection of the material arose from the varied age at which the children commenced attendance, the varied length of attendance, and the question of the serious illness or death of the child during its attendance at the consultation or soon after the cessation of its visits. It was finally decided to exclude (*a*) all infants who were over four months of age at the time of their first attendance ; (*b*) all who did not attend over a period of at least four months with regularity ; (*c*) all babies who were suffering from constitutional diseases, or who developed such during their attendance at the consultation ; and (*d*) to exclude all babies who died during their attendance at the consultation, owing to the difficulty of ascertaining how far they had been initially healthy babies.

Figures kindly supplied to me by Dr. Ballin, which are not here reproduced, confirm the conclusion, at which I had independently

arrived, that the exclusion of babies mentioned under (*d*) above did not materially affect the statistics.

Analysis of the Material.—The material has been analysed with the view of showing the age of the babies at their first attendance at the consultation, and also how long they remained under the care of the medical officers of the consultation.

The day of age of the babies has been worked out for each attendance (as already explained) upon the copies of the consultation charts.

A table was then constructed of the day of age of the children at their first attendance and of the age at which they ceased attending the consultation.

It was then apparent that the duration of attendance of the infants which were brought up at the same day of life, was so varied that it would be impossible to construct a table of any reasonable form which would give the length of attendance in weeks, much less days. Further the calculation of the age of an infant in weeks becomes somewhat inaccurate towards the later months of the first year, owing to the difference between the calendar and lunar month. Thus 36 weeks is nearer eight calendar months than nine, and thus "weeks" gives a false impression of the age. A month of 30 days was therefore taken as the unit of attendance in the table given below. Thus the age of life from 180–210 days is taken as from the 6–7 month of age. Any child leaving the consultation between those days of life, comes under the column dealing with the 6–7 month, and so on. Many of the cases attended up to 13 months of age or even rather over but they have not been dealt with over 12 months of age.

The unit of grouping for the first attendances has been taken as one week (seven days), since where only 120 days (four months) (the limit of age allowed in this research for the first attendance) were being dealt with, (see p. 31), 30 days is evidently too large a unit. As 120 days is between 17 and 18 weeks, 18 weeks have been entered upon the table, although 120 days was the figure taken in collecting the material.

It seemed of interest to give the actual number of children who attended for the first time upon each day of life, and therefore a special column (column II.) gives the actual numbers of children who were brought up for the first time on each consecutive day of age of the period of seven days under consideration.

The length of time of breast-feeding in both series evidently requires consideration, but it could not be given in the same table, and is therefore given separately below. (See pp. 34, 35.)

In the tables given (Tables I. and II.)—

Column I. gives the age of the babies at the first attendance at the consultation grouped in periods of one week (seven days).

Column II. gives the actual number of children who were brought up for the first time on each of the consecutive

days, of the period of seven days of column I. Thus the number of children who were 25 days old when first brought up would be given by the fourth figure of the fourth period of seven days.

Column III. gives the ages of the children on leaving the consultation which had been first brought up at the age given in column I. grouped in periods of 30 days.

Column IV. gives the total number of children which were brought up for the first time during the period of age given in column I.

Table I.

Showing the age of first attendance and of leaving the Consultation of the Babies of the Control or Breast-fed Series.

I. Age in weeks.	II. No. brought at each day.	III. Age on leaving (in months).							IV. Total in each week.
		4–5.	5–6.	6–7.	7–8.	8–9.	9–10.	10–12.	
1	3. 2. 0. 3. 0. 4. 4.	2	1	1	0	4	0	8	16
2	5. 7. 8. 6. 6. 7. 10.	9	4	5	3	1	3	24	49
3	8, 11, 9, 15, 12, 5, 7.	8	11	5	6	8	9	20	67
4	9. 4. 3. 8. 0. 3. 4.	2	3	7	5	1	2	11	31
5	1. 2. 4. 5 2. 3. 2.	—	1	3	1	2	1	11	19
6	5. 2. 3. 5. 2. 2. 3.	—	6	3	1	3	0	9	22
7	3. 1. 2. 3. 4. 2. 2.	—	4	1	5	1	2	4	17
8	1. 2. 1. 0. 3. 3. 0.	—	3	2	2	1	0	2	10
9	2. 2. 3. 4. 3. 2. 2.	—	3	6	2	2	1	4	18
10	1. 1. 1. 1. 2. 0. 1.	—	—	3	1	1	0	2	7
11	2. 4. 3. 3. 0. 0. 1.	—	—	4	1	1	1	6	13
12	3. 0. 0. 0. 3. 5. 1.	—	—	—	4	1	2	5	12
13	2. 1. 0. 1. 2. 0. 2.	—	—	—	1	0	2	5	8
14	1. 1. 0. 0. 0. 0. 2.	—	—	—	1	0	1	2	4
15–18	—	—	—	—	—	3	1	3	7
		21	36	40	33	29	25	116	300

This table shows that comparatively few of the children attended only the minimum period of 120 days. The actual number of such cases was 28 in all, made up of

11 babies whose first attendance was at an age of from 1–30 days.
9 „ „ „ „ „ 30–60 „
7 „ „ „ „ „ 60–90 „
1 baby „ „ „ „ 90–120 „

Twenty-one of these babies appear in the first column of column III which gives the numbers who attended up to the age of from 120–150 days, and seven babies in the other columns of column III.

Table II.

Showing the age of first attendance and of leaving the Consultation of the Babies of the boiled cows' Milk Series.

I. Age in weeks.	II. No. brought at each day.	III. Age on leaving (in months).							IV. Total in each week.
		4–5.	5–6.	6–7.	7–8.	8–9.	9–10.	10–12.	
1	2. 0. 0. 1. 2. 0. 2.	1	0	1	1	0	0	4	7
2	2. 1. 1. 1. 5. 7. 2.	0	1	4	2	0	3	9	19
3	6. 4. 3. 8. 2. 4. 2.	0	1	3	0	1	2	22	29
4	6. 2. 4. 4. 4. 4. 3.	3	3	2	1	3	1	14	27
5	1. 1. 3. 1. 4. 2. 4.	0	0	2	0	1	3	10	16
6	1. 2. 1. 2. 4. 1. 1.	3	0	2	3	0	1	3	12
7	1. 2. 2. 2. 2. 0. 5.	—	—	1	2	0	1	10	14
8	1. 3. 2. 3. 3. 2. 4.	—	—	—	2	0	2	14	18
9	2. 0. 3. 4. 2. 0. 2.	—	—	2	1	2	2	6	13
10	0 3. 2. 1. 1. 0. 2.	—	—	—	1	0	1	7	9
11	0. 3. 1. 1. 1. 0. 2.	—	—	1	2	2	1	2	8
12	0. 3. 1. 0. 0. 1. 1.	—	—	—	2	0	0	4	6
13	1. 2. 4. 0. 1. 1. 1.	—	—	1	1	2	1	5	10
14	1. 1. 1. 1. 1. 1. 0.	—	—	—	—	—	1	5	6
15–18	——	—	—	—	—	3	1	6	10
		7	6	19	18	13	20	121	204

Here still fewer children attended only the minimum number of days, but three attended a few days under the 120.

Including these three, in all nine babies attended the minimum time and these were as follows :—

4 babies whose first attendance was at an age of from 1–30 days.
3 „ „ „ „ 30–60 „
2 „ „ „ „ 60–90 „

Seven of these children appear in the first column of column III. where the numbers who attended up to the age of from 120–150 days are given.

These tables show that the great majority of children attended well over the minimum period of 120 days, or four months. All the children who attended up to from 8–9 months of age, must evidently have attended over four months.

On this basis adding together the figures in the last three columns of column III. it is seen that in the control or breast-fed series 170 children attended over four months. While in the other series or boiled milk series 154 babies attended over four months. This, however, does not give the full number, since in the other columns of column III. there are many children who had already attended many more than four months at the age of eight months.

Length of Breast-feeding.—In the control or breast-fed series of babies, all had been breast-fed for at least four months ; about 10 of these children were having *allaitement mixte* part of this time, but as it is impossible to take every minor point into consideration this was ignored. Moreover this series was taken as a general control, and not as a purely breast-fed series.

Age of Weaning in Control Series.—In this series there were in

all 52 babies who were weaned between the ages of four and six months. The rest were weaned at about nine months of age.

Age of Weaning in the Series of Babies fed upon Boiled Cows' Milk.—In this series, out of 204 babies—

78 had never been breast-fed.
41 had been breast-fed for periods varying from 1–8 days.
15 had been breast-fed for periods varying from 9–14 days.
40 had been breast-fed for periods varying from two weeks to two months.
17 had been breast-fed for periods of over two months, but under four months.
13 had been breast-fed once or twice a day for a few weeks after birth, but otherwise had had only boiled cow's milk.

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Analysis of the Medical Notes upon the Health of the Babies which attended the Consultation.—Before proceeding to the results obtained from the material itself the health of the babies under review must be considered. It has already been stated that the minor ailments although noted upon the charts, have been ignored. But the notes upon the condition of the babies as regards rickets are of interest. These are of course only of use where the child attended up to from 9–10 months of age. There are a few notes as to rickets in the children under this age, but these will be neglected, and only the notes of the older children will be considered. Every baby who is still attending the consultation at the age of 12 months, is examined for rickets, and if no note is entered it means that no evidence of this trouble could be detected. (Dr. Ballin explained to me that this was the usual routine of the consultation.)

The remarks fall into several main headings, including teeth, no teeth, rickets, rickets with teeth, and rickets but stands.

Taking the babies who were still attending at the age of from 10–12 months, it is seen from the analysis of the cases just given that 116 babies of the control or breast-fed series, and 121 babies of the boiled milk series, were still attending at that age.

Only the remarks as to the presence of rickets need be considered, the other cases being taken as healthy. Tabulating the notes the following figures are obtained—

Number of children noted as showing

	In the control series.	In the boiled milk series.
No teeth ...	2	5
Rickets ...	7	15 and 1 ?
Rickets with teeth	16 and 2 ?	11 and 2 ?
Rickets but stands	5	5 ? rickets.
	30 and 2 ?	31 and 8 ?

If failure to cut a tooth by the age of 10 months be taken as a sign of rickets, then out of 116 babies of the first series there were 30 babies who showed definite evidence of rickets, and 2 where it was doubtful.

In the boiled milk series there were 31 out of 121 babies which had definite rickets, and 8 which were doubtful.

Whichever way the figures are taken they are too close to admit of any deductions as to any greater incidence of rickets as a result of feeding upon boiled milk as compared with breast-feeding. Nor are a series of 116 and 121 cases large enough for this purpose. All that can be said is that, as far as the figures of these particular cases go, there is no evidence of any greater frequency of rickets among the babies fed upon boiled cows' milk than in those fed upon the breast. The percentage of Berlin babies which are suffering from rickets is known to be high.

In this connection compare Escherich (p. 26).

Results obtained by working up the Material.—In working up the material which had been obtained from the Berlin consultation the first point was to add the weights of all the babies of each series at the same day of life, and then divide by the number of babies weighed, thus obtaining the average weight of the babies under consideration at the same day of life.

The average weights so obtained showed considerable inequalities, and the number of average weights thus obtained was unwieldy and cumbersome. It was therefore decided to take the unit of age as eight days, and to group together all the weights of the babies from 1–8, 9–16 days of age and so on up to 368 days of age.

The total weights of all the babies which were weighed in each eight-day period of life were divided by the total number of babies weighed. Thus the average weight of all the babies of each series for consecutive periods of eight days of life up to one year of age was obtained, the inequalities of the averages for each day being thus smoothed out and the number of average weights reduced to a convenient number for plotting on a curve.

No serious overlapping of weighings was produced by this method, since the babies were usually brought up at intervals of eight or ten days, so that it was only in exceptional cases that the weight of the same baby was recorded twice in any period of eight days.

Table III. shows the results obtained by thus working up the babies of the control or breast-fed series, and Table IV. the corresponding results for the babies of the boiled cows' milk series.

In these tables

Column I. shows the age in periods of eight days of the babies considered.

Column II. given the number of observations, *i.e.*, the number of babies which were weighed upon each of the consecutive days of each period of eight days; the figures being given in chronological order.

Column III. gives the total number of observations (weighings) in each period of eight days, as given in column I.

Column IV. gives the average weight of the babies of each series for each period of eight days corresponding to the period of column I.

NOTE.—As regards Column II., in collecting the weights of the babies the weights were worked up for each day separately up to 100 days of age, from 100–224 days of age they were worked up in two-day periods, and from 224–368 days the weights were worked up in four-day periods. This is shown in the tables.

The average weights found, and shown in Tables III. and IV. are plotted on Diagram I.

The total number of observations worked up for the cases in Series I. amount to 6,297 and for Series II. to 5,444.

Table III.

Showing the average weights of the babies of the control or breast-fed series, grouped in periods of eight days, and the number of observations made.

I. Age in days.	II. No. of observations on each day.	III. Total No.	IV. Average Weight.
			Grammes.
1–8	3. 2. 0. 4. 0. 4. 6. 5.	24	3,185
9–16	10 10. 9. 11. 11. 12. 12. 22.	97	3,317
17–24	16. 21. 23. 19. 19. 20. 13. 13.	144	3,507
25–32	20. 24. 16. 19. 20. 19. 31. 18.	167	3,746
33–40	16. 19. 19. 27. 23. 25. 18. 15.	162	3,939
41–48	29. 18. 27. 19. 19. 24. 29. 27.	192	4,119
49–56	18. 19. 33. 25. 19. 18. 26. 17.	175	4,291
57–64	29. 29. 31. 24. 30. 29. 25. 27.	224	4,443
65–72	23. 20. 35. 27. 27. 25. 27. 35.	219	4,638
73–80	26. 24. 28. 19. 32. 34. 31. 21.	215	4,737
81–88	34. 40. 27. 29. 31. 25. 26. 26.	238	4,937
89–96	35. 22. 41. 32. 27. 30. 23. 22.	232	5,079
97–104	26. 27. 25. 33. 61. 52.	224	5,191
105–112	54. 58. 45. 60.	217	5,380
113–120	54. 54. 58. 50.	216	5,666
121–128	60. 57. 61. 53.	231	5,659
129–136	52. 61. 59. 55.	227	5,757
137–144	60. 48. 56. 56.	220	5,929
145–152	47. 50. 51. 43.	191	6,033
153–160	47. 56. 45. 43.	191	6,237
161–168	50. 50. 45. 39.	184	6,274
169–176	47. 47. 48. 40.	182	6,312
177–184	41. 41. 46. 43.	171	6,434
185–192	41. 32. 27. 47.	147	6,458
193–200	32. 28. 41. 27.	128	6,664
201–208	32. 37. 29. 35.	133	6,709
209–216	31. 31. 30. 28.	120	6,734
217–224	32. 37. 35. 32.	136	6,798
225–232	54. 56.	110	6,778
233–240	55. 54.	109	6,886
241–248	58. 42.	100	6,891
249–256	42. 47.	89	7,118
257–264	38. 40.	78	7,276
265–272	46. 40.	86	7,217
273–280	43. 38.	81	7,388
281–288	36. 41.	77	7,281
289–296	28. 35.	63	7,608
297–304	34. 38.	72	7,567
305–312	36. 32.	68	7,801
313–320	22. 36.	58	7,555
321–328	32. 26.	58	7,753
329–336	37. 20.	57	7,704
337–344	26. 22.	48	7,752
345–352	21. 22.	43	8,034
353–360	22. 15	37	8,077
361–368	19. 15.	34	8,274

Table IV.

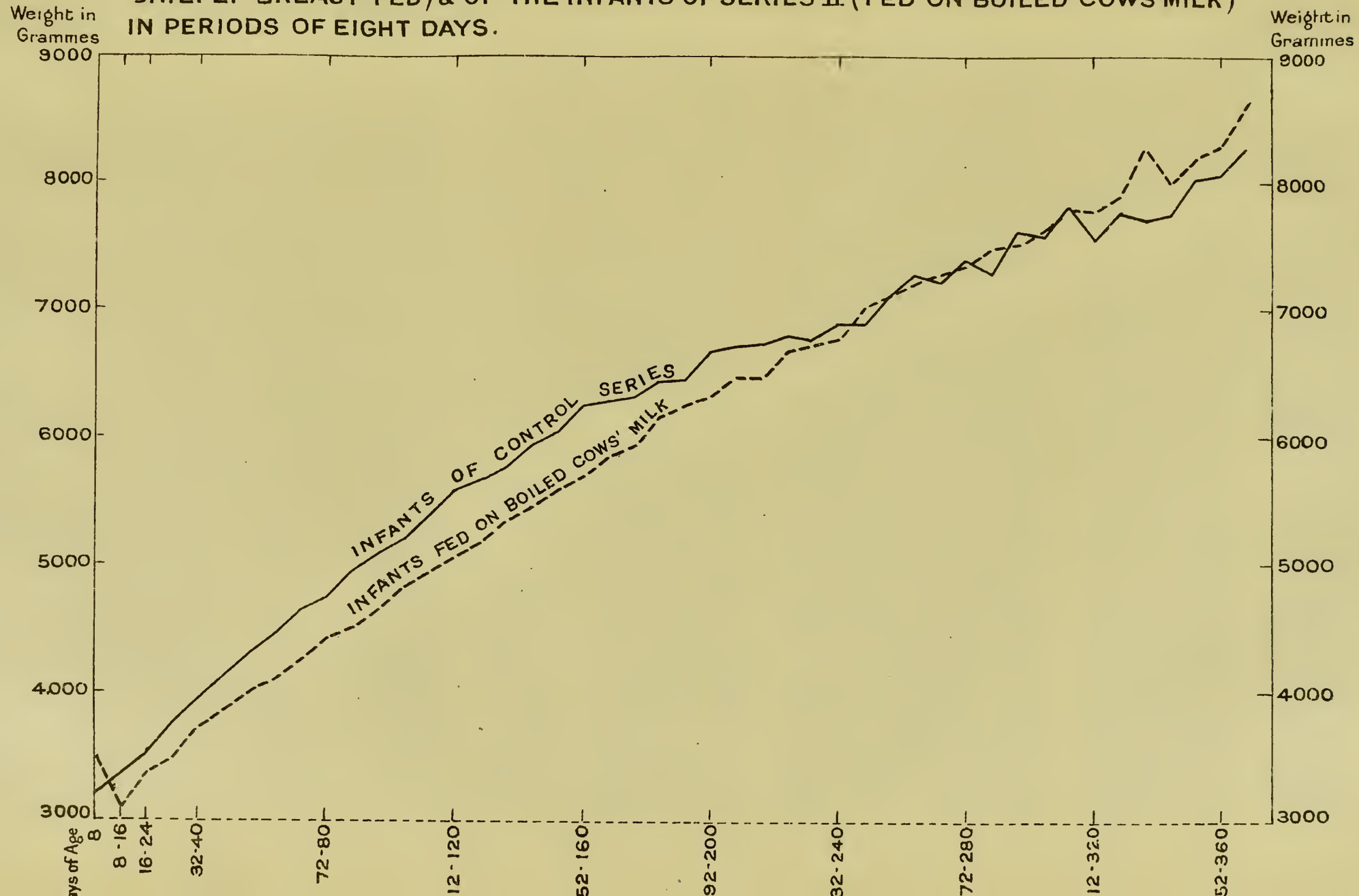
Showing the average weights of the babies of the boiled cows' milk series, grouped in periods of eight days, and the number of observations made.

I. Age in days.	II. No. of observations on each day.	III. Total No.	IV. Average weights.
			Grammes.
1–8	2. 0. 0. 1. 2. 0. 3. 2.	10	3515
9–16	2. 3. 2. 6. 7. 5. 9. 6.	40	3090
17–24	7. 11. 6. 15. 11. 13. 4. 9.	76	3358
25–32	15. 17. 15. 14. 14. 13. 11. 14.	113	3472
33–40	15. 14. 15. 14. 17. 17. 15 18.	125	3708
41–48	12. 13. 21. 13. 17. 15. 23. 17.	131	3848
49–56	15. 23. 16. 16. 17. 21. 17. 18.	143	3991
57–64	23. 14. 26. 21. 18. 12. 19. 19.	152	4082
65–72	21. 20. 21. 20. 15. 23. 15. 20.	155	4240
73–80	22. 20. 24. 20. 20. 22. 22. 9.	159	4407
81–88	25. 16. 26. 31. 20 24. 26. 28.	196	4486
89–96	18. 13. 34. 16. 26. 21. 32. 25.	185	4628
97–104	15. 22. 30. 10. 55. 30.	162	4814
105–112	47. 49. 39. 38.	173	4935
113–120	46. 46. 44. 42.	178	5052
121–128	41. 53. 40. 45.	179	5171
129–136	46. 38. 46. 41.	171	5326
137–144	41. 45. 43. 35.	164	5436
145–152	40. 40. 41. 41.	162	5569
153–160	47. 40. 37. 36.	160	5669
161–168	36. 45. 40. 27.	148	5831
169–176	45. 41. 39. 39.	164	5915
177–184	29. 38. 41. 36.	144	6146
185–192	33. 33. 37. 37.	140	6242
193–200	36. 37. 34. 31.	138	6319
201–208	67. 62.	129	6475
209–216	77. 53.	130	6467
217–224	68. 65.	133	6677
225–232	66. 67.	133	6721
233–240	52. 59.	111	6770
241–248	62. 52.	114	7010
249–256	53. 70,	123	7112
257–264	37. 57.	94	7204
265–272	53. 41.	94	7274
273–280	39. 41.	95	7347
281–288	48. 43.	91	7481
289–296	37. 48.	85	7512
297–304	40. 39.	79	7610
305–312	42. 42.	84	7788
313–320	28. 34.	62	7765
321–328	40. 27.	67	7887
329–336	36 28.	64	8281
337–344	28. 31.	59	7985
345–352	20. 23.	43	8194
353–360	27. 21.	48	8281
361–368	25. 13.	38	8613

Analysis of the curves of Diagram I.—Diagram I. shows at once that a considerable divergence between the two curves starts in the early days of life, and continues well-marked up to about the 208th day, after which it disappears fairly rapidly. The question

DIAGRAM I.

SHOWING THE AVERAGE WEIGHTS OF THE INFANTS OF SERIES I (CONTROL SERIES, CHIEFLY BREAST-FED) & OF THE INFANTS OF SERIES II (FED ON BOILED COWS' MILK) IN PERIODS OF EIGHT DAYS.



suggested by these curves is,—Is the difference between the average weight of breast-fed and of babies of the same age fed upon boiled cows' milk due to the method of feeding?

Diagram I. would seem to have answered this question affirmatively. Before, however, stating this definitely to be the case, it is advisable to consider whether some other factor may not be concerned, to which this difference can be attributed.

Such a factor might be the error due to the so-called "Error of Sampling." If this error is significant, then the curves may have a different interpretation to the apparently obvious one, and it therefore becomes essential to examine the importance of this factor, before proceeding to draw deductions from the curves as they stand in Diagram I.

*Analysis of the Data by Statistical Methods.**—In dealing with the error of sampling the important point will evidently be to ascertain how much the mean value obtained from the observations as shown on the curves is likely to differ from the mean of all babies in the same class, that is to say what is the probable error of the mean.

Suppose M_1 and M_2 are the means of the two sets of observations, then the accuracy of each must evidently depend upon

(*a*) The number of observations upon which it is based, and

(*b*) The divergence of these observations from their mean value.

In statistical work the expression $\cdot 67449 \frac{s}{\sqrt{N}}$ is taken to represent the probable error, where s = the square-root of the average of the squares of the distances of the observations from the mean, and is known as the "Standard Deviation," and where N = the number of observations. (Cp. Yule. Introduction to the Theory of Statistics. Chaps. VII. and XVII.)

The measures of reliability or the "probable errors" for the two means will be $\cdot 67449 \frac{s_1}{\sqrt{N_1}}$ and $\cdot 67449 \frac{s_2}{\sqrt{N_2}}$ respectively. These expressions may be called E_1 and E_2.

Experience has shown that unless the difference between M_1 and M_2 is at least two or three times as great as $\sqrt{E_1^2 + E_2^2}$ then it is not safe to assert that the difference found is really significant; it might be due to an error of sampling.

This method is only strictly speaking applicable when the variables, *i.e.*, the observations are "normally" distributed (vide Yule, op. cit. Chap X.) but it may fairly be used as a sufficiently accurate test for material such as the present.

This test of the error of sampling has been applied over three periods of eight days, in each of the series. The three periods selected were the three consecutive periods included from the 137th to the 160th day after birth. These periods were selected as being those where there were a large number of observations in both series, and where the numbers of each series were most nearly equal.

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* For instruction in the statistical methods employed and for supervision of the results obtained I am deeply indebted to Dr. Major Greenwood, Junr., of the Lister Institute, and have much pleasure in thanking him for his most valuable help.

The unit of grouping taken was 200 grammes, and the results obtained are given in the accompanying table.

Days of age.	Mean weight (in grammes).		Difference $M_1 \sim M_2$ (in grammes).	Probable error.		Value of $\sqrt{E_1^2+E_2^2}$.	Ratio of $\frac{M_1 \sim M_2}{\sqrt{E_1^2+E_2^2}}$
	Series I.	Series II.		Series I.	Series II.		
137–144	5,929	5,436	495	44·98	44·59	63·6	7·8
145–152	6,033	5,569	455	43·84	41·20	60·1	7·6
153–160	6,237	5,669	548	48·25	44·00	65·1	8 4

The mean of these observations bears therefore such a ratio to the value of $\sqrt{E_1^2+E_2^2}$ as to show clearly that the difference between the mean values of the two series can hardly be due to an error of sampling.

It appears that there is a difference between the values obtained for the series of babies fed upon the breast and for those fed upon boiled cows' milk, and that this difference can hardly be attributed to errors of sampling. It does not, however, necessarily follow that the difference of food has been the causative factor, and it becomes necessary to ask whether there can be any other factor at work which is producing the difference found.

The question of the health of the children need not be taken into consideration since the children were all, as far as it was possible to judge from the careful medical notes, in a good state of health.

The social class of the children seemed a possible factor, and in spite of the fact that the parents of the children all belonged approximately to the same social class, it was considered advisable to investigate the possible significance of any difference which existed between the social conditions of the homes.

Nothing very striking in this direction could be expected at the outset, since in no case was the family in circumstances of more than moderate comfort, such persons not being encouraged to attend the consultation, and only being received in quite exceptional cases. On the other hand no infant was allowed to suffer from any deficiency of food, since in cases of poverty the milk for the infant is supplied free by the town. Hence the question of possible relative starvation does not come in at all.

In order to arrive at the significance, if any, of the social conditions upon the observed difference in the weight of the two series of babies, it was necessary to investigate the relation between the weight of the infant, the wages of the father, and the method of feeding.

For this purpose the weights of the babies of both series at the age of 137–144 days of life were taken. Illegitimate infants and those of families who were living upon the wages of the mother, were omitted, as not being entirely comparable. 345 observations were available for this purpose.

The correlations between the three variables taken in pairs were found to be—

*(1) For artificial feeding and wages, ·16.

*(2) For artificial feeding and weight of child, — ·28.

†(3) For weight of child and wages of father, — ·02.

The correlation between weight of the child and the method of feeding was determined, the wages of the father being kept constant, (coefficient of partial correlation, *vide* Yule, *op. cit.*, pp. 225–249) and the figure obtained was — ·29 ± ·03, and the correlation between wages of parents and weight of the infant, keeping the feeding constant, is — ·026 ± ·036.

It would appear therefore that the weight of the child is more closely associated with the nature of the food than with the social class, as indicated by the wages of the father.

It must, however, again be emphasised that we are here dealing with a class of persons who are by no means a random sample of the population, but are almost a selected social class. A table of the wages of the parents as found to be distributed in making out the correlation of the feeding in relation to the wages is given below (see Table VI) ; it might appear at first sight that this table shows a considerable range of distribution since the wages show a variation of from 10–42 marks a week. A further examination will show that the great majority of the fathers were earning from 20–30 marks a week, that is to say, they were earning the average artisan wage, and the cases taken belong as a whole to a definite class of the population ; it would be hardly possible to confine the cases to a smaller range of wages than 20–30 marks a week. The cases falling below this figure are rendered more equal than appears from the table by the fact that no baby is allowed to have a deficient food-supply, since if it is artificially-fed the milk is supplied free if the family cannot afford to pay for it, and the nursing mothers receive a nursing bonus, and if necessary may receive a further subsidy.

The question of environment may have some influence in this connection since presumably a family earning 15 marks a week will not live in such sanitary rooms as one earning 30 marks, but this is again partly mitigated by the regular visits of the health visitor, who endeavours to procure fresh air and cleanliness for the child.

Hence these figures, although of interest, cannot be used for more general deductions as to the relation of the weight, wages, and method of feeding of the infant population as a whole. It is fairly certain that, inasmuch as few of the more prosperous artisans attend the consultation the correlation between weight of infant and wages is less than would have been found in the general population. Even, however, assuming that the infants attending the consultation belonged to much more widely distributed social strata, it is unlikely that the correlation would be raised to any value approaching that

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* Determined by the method of Pearson ([53]) (in Biometrika VII., 1909, p. 96).

† Determined by the ordinary product-moment method. (Cp. Yule ([68]), *op. cit.*, Chap. IX.)

The — ve sign indicates that body-weight decreases as the proportion of artificially-fed babies increases.

found for the correlation between the method of feeding and the body-weight. Moreover this last correlation would probably be higher in the general population.

The distribution of the weight in relation to the food of the infants under consideration is given in Table V and shows that the maximum of the weight-frequency occurs at a lower level of weight in the boiled cows' milk series than in the breast milk series. Table VI gives the distribution of the feeding in relation to wages.

In both Tables V and VI there are only 345 observations in a total number of 504 children owing almost entirely to the fact that a number of the children did not happen to come up for weighing at the age of life which was taken, namely, from 137–144th day of life. Only a very few children were omitted because of illegitimacy or because the mother was the wage-earner of the family.

Table V.

Showing the distribution of the Observations on the Weight of Infants in relation to their Food at the 137–144*th day of life.*

Weight of Infants in grammes.	Number of Infants having such a weight		
	In breast milk series.	In boiled milk series.	Total.
3000–3200	1·0	·5	1·5
3200–3400	1·0	·5	1 5
3400–3600	0	0	0
3600–3800	4·0	2·5	6·5
3800–4000	3·0	3·5	6·5
4000–4200	6·0	3·5	9·5
4200–4400	3·0	6·0	9·0
4400–4600	2·0	4·0	6·0
4600–4800	6·5	8·5	15·0
4800–5000	8·0	9·5	17·5
5000–5200	10·0	11·0	21·0
5200–5400	10·0	10 5	20·5
5400–5600	13 5	10·5	24·0
5600–5800	14·0	17·5	31·5
5800–6000	16·5	16·0	32·5
6000–6200	19 0	15·5	34·5
6200–6400	20·5	4·5	25·0
6400–6600	11·0	7·0	18·0
6600–6800	18·0	3·0	21·0
6800–7000	10·0	4·0	14 0
7000–7200	13·5	·5	14·0
7200–7400	6·5	·5	7·0
7400–7600	—	·5	·5
7600–7800	3·0	·5	3·5
7800–8000	2·5	—	2·5
8000–8200	·5	—	·5
8200–8400	1·5	—	1·5
8400–8600	·5	—	·5
	205·0	140·0	345·0

Table VI.

Showing the distribution of the Observations on the Feeding of the Infants in relation to the Wages.

Weekly Wages of Father in Marks.	Number of Fathers earning such weekly wage		
	In breast milk series.	In boiled milk series.	Total.
10	1·0	·5	1·5
11	4·0	2·5	6 5
12	0·0	0·0	0·0
13	·5	·5	1·0
14	·5	·5	1·0
15	3·0	0·0	3·0
16	·5	·5	1·0
17	2·0	1·0	3·0
18	2·5	2·5	5·0
19	7·0	2·0	9·0
20	22·5	13·0	35·5
21	20·5	7·0	27·0
22	31·0	15·5	46·5
23	28·0	12·5	40·5
24	17·0	14·0	31·0
25	20·5	19·5	40·0
26	8·0	5·0	13·0
27	11·0	12·0	23·0
28	9·5	9·5	19·0
29	1·5	5·0	6·5
30	10·0	13·0	23·0
31	2·0	0·0	2·0
32	·5	0·0	·5
33	·5	1·0	1·5
34	—	—	0·0
35	—	2·0	2·0
40	1·0	1·0	2·0
42	1·0	—	1·0
	205·0	140·0	345·0

The following inferences may be drawn as to the divergence of the two curves in Diagram I up to the 208th day :—

(1) There is a significant difference between the average weight of infants fed upon the breast and upon boiled cows' milk, in favour of the former ; and

(2) An important factor in this result is the method of feeding.

The curves of Diagram I may be divided into three parts, namely :—

(1) The first part where the curves cross and then diverge ; the curve of the boiled milk series, which starts above the curve of the breast-fed series, falling rapidly below this latter curve.

(2) The second part of the curves where the two curves run approximately parallel from about the 24th to the 200th day of life, and

(3) The last part of the curves where the divergence is obliterated, the subsequent tendency being for the curve of the boiled cows' milk series to show a value a little above that of the breast-fed series.

From the preceding statistical analysis it appears that the divergence of the *middle part* of the curve is to be attributed essentially to the difference in the method of feeding of the two series.

The first and third parts of the curves remain for consideration and will now be dealt with, the first part being taken first.

Further Analysis of the First Part of the Curves of Diagram I.— At no part of the curves is the tendency to diverge so markedly shown as in the first part of the curves, during a period extending over the first three of the eight-day periods of life. The average weight of the breast-fed babies shows a rise from the first, while that of the babies fed upon boiled cows' milk falls throughout the two first eight-day periods, and shows no rise above the first eight-day period until the 33–40th days of life.

It is a matter of common knowledge that every baby loses weight during the first few days of life, and a drop in the average weight of the breast-fed babies in the second eight-day period was almost to be expected. This possible fall in the curve is concealed to some extent by the grouping of the weights into periods of eight days, the first period including the period of fall in weight. In many of these cases the observations would commence at a time when the loss of weight after birth had already taken place, and the child was again beginning to increase in weight. The absence of fall in the curve of the breast-fed babies can therefore be explained.

When a comparison is made between the two curves, it appears that while one curve rises the other falls, and evidently there is either some fundamental factor or factors at work producing this difference, or some source of error has crept into one or both of the curves.

It was considered desirable first to eliminate any possible source of error. The same source of error as was sought for in the middle part of the curves may evidently be at work in this part of the curves, namely, the error of sampling, and this was therefore investigated.

Statistical Examination of the Average Weights obtained in the first four periods of Eight Days.

The same method and notation as were used in dealing with the middle part of the curves was applied, viz. :—

N = Number of observations.

s = Standard deviation.

E = Probable error, and is represented by the expression

$$\cdot 67449 \frac{s}{\sqrt{N}}$$

M_1 and M_2 are the means of the two series, their difference being "D."

By this method the following values were obtained and are tabulated below :—

—	Days of Age.	Mean (in grammes).	Standard Deviation.	Probable Error.	$\sqrt{E_1^2+E_2^2}$	$\frac{D}{\sqrt{E_1^2+E_2^2}}$
Series I ...	1–8	3,185	622	85·8		
		D=330			122·0	2·7
Series II ...	1–8	3,515	410	87·4		
Series I ...	9–16	3,312	544	37·3		
		D=222			60·5	3·7
Series II ...	9–16	3,090	452	48·3		
Series I ...	17–24	3,512	632	35·4		
		D=145			49·5	2·92
Series II ...	17–24	3,367	460	35·7		
Series I ...	25–32	3,745	652	34·1		
		D=272			47·5	5·7
Series II ...	25–32	3,473	522	33·1		

The average weight of the babies fed upon boiled cows' milk is higher for the first eight-day period than that of the breast-fed babies. The former value is based upon 10 observations, and the latter upon 24 ; it becomes a question whether any importance can be attributed to this difference in average weight or whether it may not be due to an error introduced by the extremely small number of observations available for the boiled cows' milk series.

Ten observations are not sufficient for the formula given in the above table of results to be justifiably employed, since the reliability of the method is exaggerated when the number of observations is very small.

The method introduced by " Student " ([61]) is applicable for small number of observations. It is based upon the probability of the occurrence of the mean value obtained by the ordinary method among the average population.

Taking $3185 \pm 85{\cdot}8$ (the " probable error " of 3185 is 85·8) grammes as the mean weight of babies in the average population it appears that the chance of 10 observations from such a population having a mean of 3515 grammes with a standard deviation of 410 is 1 in 50. Suppose, however, that the mean weight of the average baby in the population were 3357 grammes, it is then found that the probability that a population with a mean weight of the babies of this age of 3357 grammes (3185 + twice the probable error, *i.e.*, 172) should give in 10 observations a mean of 3515 is 1 in 7. It may be remarked that so far as the evidence goes, there is about 1 chance in 10 that the mean weight of the controls is not less than 3359.

It seems therefore that the difference between the weights of the two series for the first eight-day period, might be considered as due to an error of sampling brought about by the extremely small number of observations available for the series of babies fed upon boiled cows' milk. It may be taken that the babies of both series whose weights were observed during this period of life can be considered as average samples of the population, the influence of

other factors, if present, which would tend to cause a divergence of the two series, being inappreciable compared with that caused by the error of sampling.

The figures of the later periods, are based upon sufficiently large number of observations for the ordinary method to be reliable.

The tabulated results show that the ratio of the difference of the means to the measure of the sum or difference of the probable errors ($\sqrt{E_1^2 + E_2^2}$) is in all cases greater than 2, and hence the difference in weight of the two series, may fairly be attributed to some factor other than the error of sampling.

A source of error might arise in respect of the distribution of the variables.

In applying the usual method, it is assumed that these are "normally" distributed; inspection of the distribution of the individual weights suggests that this condition is not accurately fulfilled, and the process is not then strictly reliable ([34]).

The figures, however, approximate sufficiently to the normal type for it to be unlikely that an appreciable error is introduced in basing the results obtained upon the application of this formula.

Some factor other than the error of sampling must therefore be sought for.

The possible influence of the social conditions has already been dealt with fully in a previous section of this report (see pp. 41, 42) in connection with the middle part of the curves, and it has been shown that in this part of the population, which is to a great extent a selected population, this is a negligible factor. It need not therefore be raised again.

The main factor for consideration will evidently be that of the feeding and it seems not unreasonable to suppose that the loss in weight which occurs in all children is on the average more prolonged in babies fed upon boiled cows' milk, than in babies fed upon the breast.

Birk ([5]), in some experiments carried out upon the metabolism of infants in the first days of life, found that the breast-fed babies he investigated had regained their birth-weight in 4 or 5 days after birth. And it appears probable from the data given above in Table III. that the average breast-fed baby regains its birth-weight at any rate within a period of eight days, since there is a marked rise in average weight during the second eight-day period.

Birk found that although an infant may show absolute loss of weight during the first few days of life, yet it is retaining nitrogen, and in the cases studied by him, at the time the child regained its birth-weight, namely at the fifth day, there was a positive nitrogen balance of 951·3 milligrammes.

This, however, only occurred with breast-fed babies who were given colostrum.

A child fed upon the milk of a wet-nurse who was in a later stage of lactation, and had no longer any colostrum, showed a negative nitrogen balance. It may well be that the colostrum is of great importance in the metabolism of infants during the first days of life. Colostrum is very rich in nitrogen, and according to Pröscher ([57]) the nitrogen content of the milk has an important relationship to the rate of growth of the young animal of many species. Griffith and Gittings ([35]) found that the loss of weight after birth could be prevented, by giving the child to a wet-nurse during the first day or two, but that after a few weeks no difference could be detected between the infant whose loss of weight had been prevented, and one whose loss of weight had been allowed to occur.

The physiological loss of weight which occurs after birth appears to be greatly accentuated in the case of children fed upon boiled cows' milk, and it seems possible that the absence of colostrum is an important factor in its causation, in addition to the disadvantage arising from the use of the milk of another species.

No data appear to be available in regard to babies fed upon the colostrum of cows, either boiled or raw ; nor any upon infants fed upon raw cows' milk either in comparison with breast feeding or with boiled cows' milk.

There are a fair number of data in regard to the causation of the loss of weight in breast-fed babies, but this is scarcely within the scope of the present report.

The difference between the curves of the two series is in all probability very intimately connected with, if not entirely due to the method of feeding, and points to the great importance of breast-feeding for infants, especially in the early days of life : this is also in entire accord with the clinical experience and has been forcibly voiced by Czerny ([20]) and many others.

Analysis of the latter parts of the curves.—The difference between the average weights of the two series begins to decrease at about the 180th day of life, and then disappears fairly rapidly, until at about the 230th day it is no longer present. From this age onward no difference between the two curves can be detected, except possibly in favour of the boiled milk series towards the end of the first year.

If Tables III. and IV. be referred to it will be seen that the number of observations is becoming smaller, and that therefore the reliability is somewhat lessened ; the numbers are however still sufficiently large for further statistical investigation to be unnecessary.

A considerable number of the healthy babies of the breast-fed series, which had been weaned at about the age of nine months, ceased attending before the end of the first year, and there is almost certainly a tendency for the less robust breast-fed babies to predominate, in this series. The babies fed upon boiled cows' milk tend on the whole to be brought up to the consultation to a somewhat later age, partly no doubt because the mother having got accustomed to getting the milk through the consultation, and knowing it to be reliable, prefers to continue getting the milk in this

manner, and partly also because, if she is poor, she gets the milk at a reduced rate.

It was stated (on p. 35) that of the 300 babies of the breast-fed series, 52 were weaned between the ages of four and six months, so that a not inappreciable number of the babies of Series I. were actually receiving the same food as the babies of the other series, during the period from the 180th day onwards.

It is not improbable also, that many of the mothers who were still feeding their infants during the period of from 6–9 months, were not giving such a free supply of milk for the infant as at an earlier period of the baby's life. It might well be that the infant was receiving sufficient milk for the needs of the organism, but not as much as was required for an optimum rate of growth, and might not be obtaining as rich a food-supply as the babies of the boiled cows' milk series, who were receiving a carefully regulated quantity of food material.

It appears from the work of Schlossmann ([59]), Budin ([12]), and Finkelstein ([30]) that many wet-nurses are capable of giving large quantities of milk over prolonged periods, amounting in some cases to 10–13 months. This is, however, not universal. There is the additional consideration that the wet-nurses are presumably in much more favorable circumstances in the regular life and food of an institution, than the mothers of the average artisan family.

In Schlossmann's cases it was found that the quantity of milk given by a woman who was considered an excellent wet-nurse, and was under very favorable circumstances increased up to about the 60–70th day of lactation, and then maintained a fairly constant and high level, up to about the 200–210th day of lactation, after which it became irregular in quantity and tended to decrease. He observed the same also in a second case.

Budin and Finkelstein's cases show a longer period of full lactation in most of the wet-nurses.

Bunge ([14]) states that the period of lactation in women is gradually becoming shorter. Without entering into this much discussed question, it may be mentioned that the age of weaning is now considerably younger than it was some time ago, before the introduction of artificial feeding. (Cp. Introduction to this report p. 2.) It may be that the optimum length of breast-feeding in the human species is the same as it always was, but that children were formerly kept upon the breast for a period exceeding the physiological period, and a high degree of under-feeding may have been the result ; the extremely high rate of mortality among young children in the middle ages and later, may have had some connection with an unduly prolonged lactation.

In this connection Silbergleit ([60]) has recently shown that among the population of Berlin as a whole, the percentage of breast-fed infants has decreased during the ten years from 1895 to 1905, and

that the percentage of bottle-fed infants has increased disproportionately for the later months of infancy. In other cases the duration of breast-feeding is becoming shorter among the population of Berlin as a whole.

It does not seem necessary to seek any further for reasons as to the causes of the disappearance of the difference between the average weights of the two series.

Under the conditions such as obtained in the consultation from whose records the observations dealt with in this report have been compiled, it seems that after the age of six to eight months no appreciable difference in weight between the breast-fed babies and babies fed upon boiled cow's milk can be detected.

It is impossible to say how far this would hold for the population at large, since as soon as the babies come under observation in the matter of weight, they likewise come under medical care and attention ; there can however be very little doubt, that this favorable result is due in a great measure to the medical care and knowledge which is available for the babies attending the Consultation.

If the average weights of the babies of both series are compared with the corresponding figures given by Camerer ([17]), it appears briefly that, neglecting the weight at birth, the rate of growth of Berlin babies given in this report is rather less than that given by Camerer. As a whole, the initial weights are higher and the final weight at the end of the first year, lower.

Compared with the figures of Finkelstein (Waisensäuglinge, p. 9) who has compared his figures with those of Camerer, it seems that the figures given in this report are intermediate in value between the average values obtained by Camerer and Finkelstein. Owing to the differences between the quantity and quality of the material used in the different sets of observations it would not be profitable to carry the comparison any further.

The percentage rate of growth of babies of both series.—It seemed desirable to study the rate of growth of the babies of the two series dealt with in this report.

This was done in the following ways :—

(1) By estimating the percentage increase per kilo. of body-weight during each period of eight days, each series being taken separately.

(2) The rate at which growth took place as measured by the time required by the babies of each series for the doubling of the initial average weight, the values of the first eight-day period being omitted on account of the small number of observations available in the series of babies fed upon boiled cows' milk.

(3) By estimating the percentage deficit of the average weight of babies fed upon boiled cows' milk as compared with the weights of the breast-fed babies. The weights of the breast-fed babies being taken as 100.

The results of the first method are given in Table VII. and are plotted in Diagram II. Both series show an extreme irregularity in the rate at which the weight increases, but after the first two estimations it would be difficult to point out any marked difference between the values of the two series.

Table VII.

Showing percentage rate of increase for each period of eight days, of the babies of both series, up to the age of eight months.

Age in days.	Breast-fed Series.			Boiled Cows' Milk Series.		
	Average Weight (in grammes).	Increase.		Average Weight (in grammes).	Increase.	
		In grammes.	Per cent.		In grammes.	Per cent.
1–8	3185	—	—	3515	—	—
9–16	3348	163	5·1	3090	—425	—12·0
17–24	3507	159	4·7	3358	268	8·7
25–32	3746	239	6·8	3472	114	3·4
33–40	3939	193	5·1	3708	236	6·8
41–48	4119	180	4·6	3848	140	3·8
49–56	4291	172	4·2	3991	143	4·1
57–64	4443	152	3·5	4082	91	2·9
65–72	4638	195	4·4	4240	158	3·9
73–80	4737	99	2·1	4407	167	3·9
81–88	4937	200	4·2	4486	79	1·8
89–96	5079	142	4·9	4628	142	3·2
97–104	5191	112	2·2	4814	186	4·0
105–112	5380	189	3·6	4935	121	2·5
113–120	5566	183	3·6	5052	117	2·8
121–128	5659	93	1·7	5171	119	2·4
129–136	5757	98	1·7	5326	155	3·0
137–144	5929	172	3·0	5436	110	2·0
145 152	6033	104	1·8	5569	133	2·4
153–160	6237	204	3·4	5669	100	1·8
161–168	6274	37	·6	5831	162	2·9
169-176	6312	38	·6	5915	84	1·4
177–184	6434	122	1·9	6146	231	3·9
185–192	6458	24	·4	6242	96	1·6
193–200	6664	206	3·2	6319	77	1·2
201–208	6709	45	·7	6475	156	2·5
209–216	6734	25	·4	6467	— 8	— ·1
217–224	6798	64	1·0	6677	210	3·2
225–232	6778	— 20	— ·3	6721	44	·7
232–240	6886	108	1·6	6770	49	·7

After this age the increase becomes very variable.

The results of the second method are shown in Table VIII. and are plotted on Diagram III., which shows that as regards rate of growth there is little to choose between the two series. The babies fed upon boiled cow's milk doubled their weight at the 185–192nd

DIAGRAM II.

SHOWING PERCENTAGE RATE OF INCREASE FOR EACH PERIOD OF EIGHT DAYS ON THE INFANTS OF BOTH SERIES (CONTROL & BOILED COWS MILK) UP TO THE AGE OF EIGHT MONTHS.

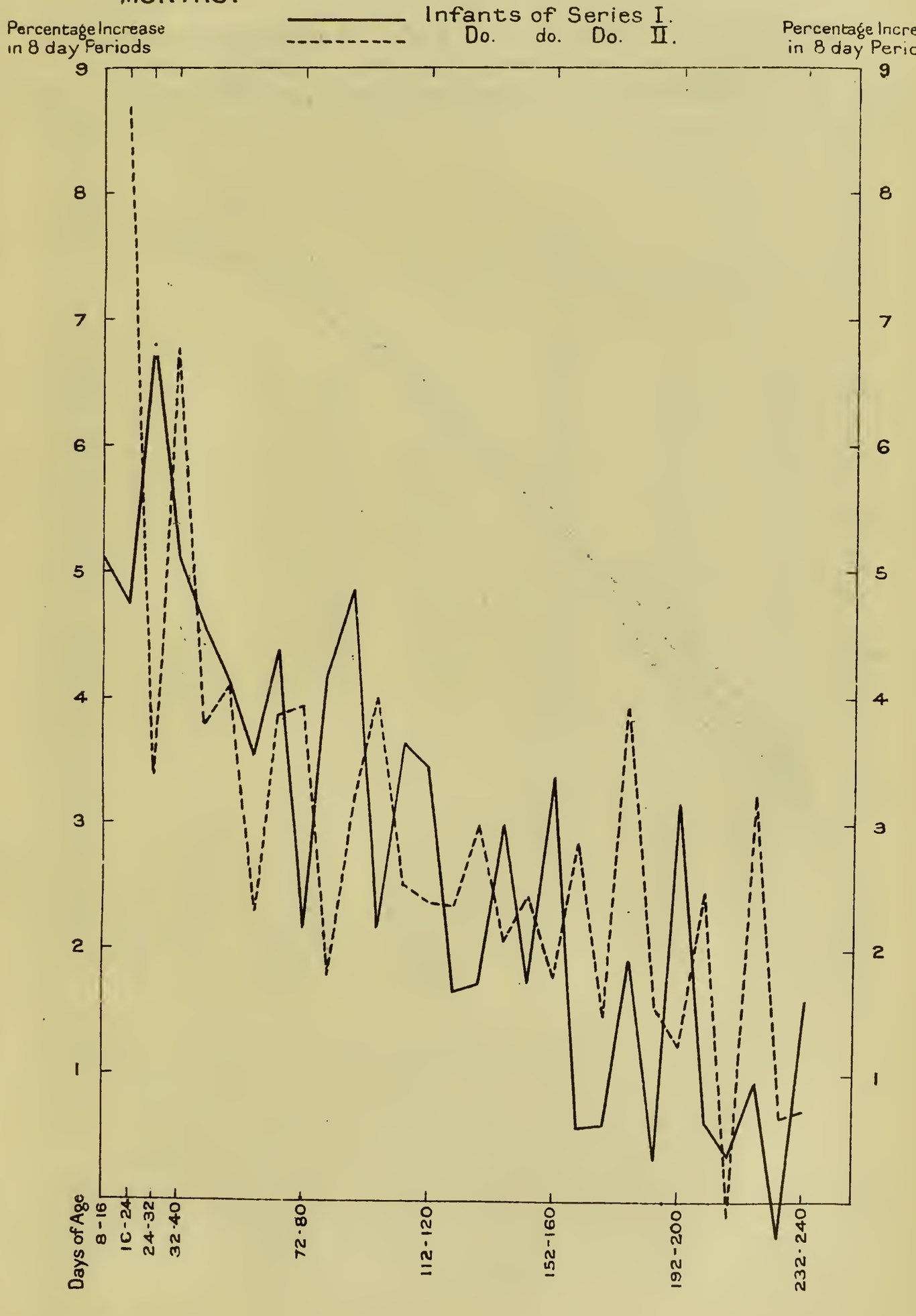

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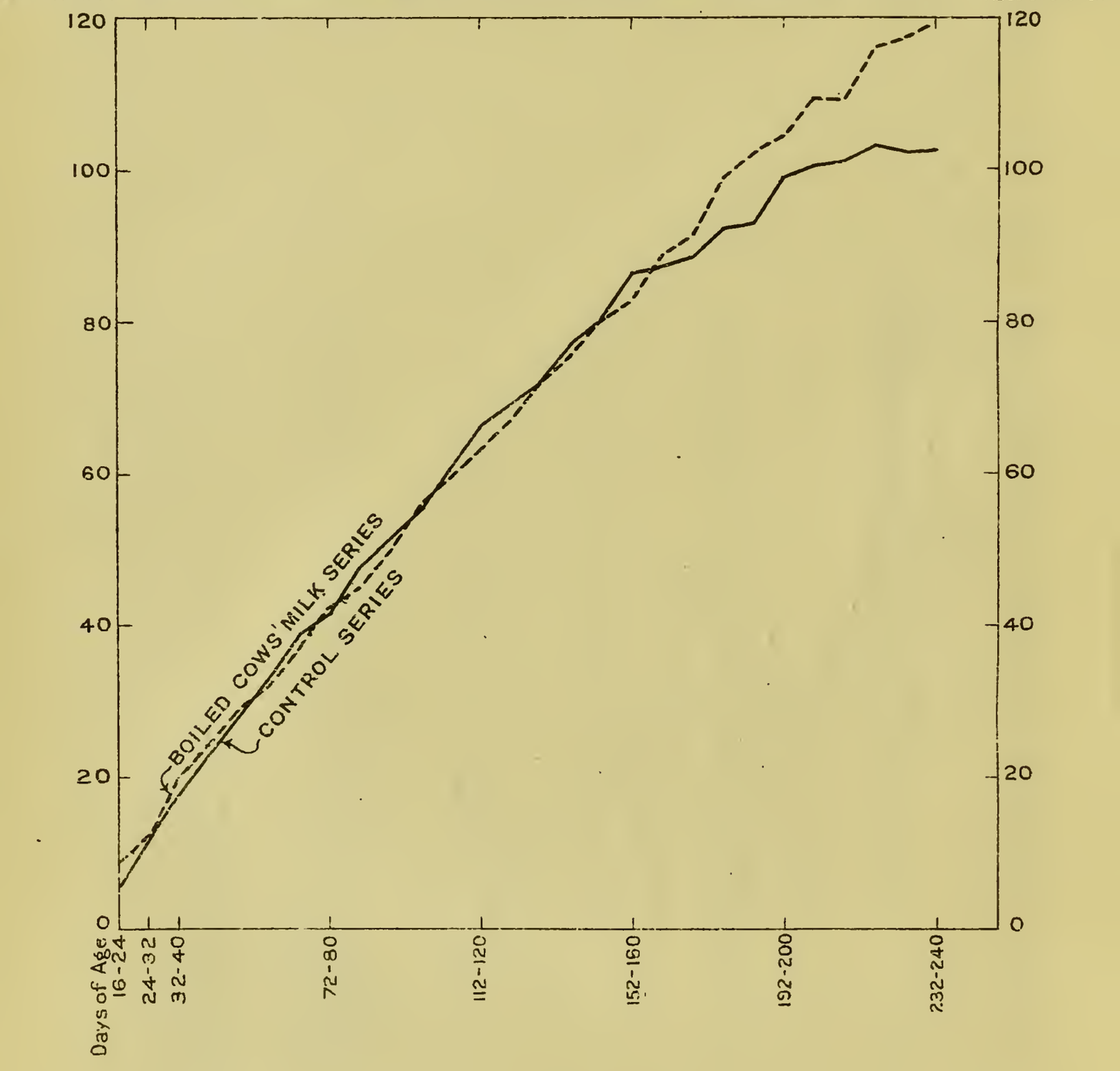
DIAGRAM III.

SHOWING THE PERCENTAGE RATE OF GROWTH OF THE INFANTS OF BOTH SERIES (CONTROL & BOILED COWS' MILK) COMMENCING AT THE SIXTEENTH DAY OF LIFE.



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day, or a fortnight earlier than the breast-fed babies, but they started with an initially lower weight, since the first value was omitted, on account of the small number of observations.

Table VIII.

Showing the percentage rate of Growth of the Babies of both series starting from the second eight-day Period of Life. Control series being the Breast-fed Babies and the other series being Babies which were fed upon Boiled Cows' Milk.

Age in days.	Control Series.			Boiled Milk Series.		
	Average Weight (in grammes).	Increase.		Average Weight (in grammes).	Increase.	
		In grammes.	Per cent.		In grammes.	Per cent.
8–16	3348	—	—	3090	—	—
17–24	3507	159	4·7	3358	268	8·6
25–32	3746	398	11·8	3472	382	12·3
33–40	3939	591	17·6	3708	618	20 0
41–48	4119	771	23·0	3848	758	24·5
49–56	4291	943	28·1	3991	901	29·1
57–64	4443	1095	32·7	4082	992	32·1
65–72	4638	1290	38·5	4240	1150	37·2
73–80	4737	1389	41·4	4407	1317	42 6
81–88	4937	1589	47·4	4486	1396	45·1
89–96	5079	1731	51·7	4628	1538	49 7
97–104	5191	1843	55·0	4814	1724	55·7
105–112	5380	2032	60·6	4935	1845	59·7
113–120	5566	2218	66·2	5052	1962	63·4
121–128	5659	2311	69·0	5171	2081	67·3
129–136	5757	2409	71·9	5326	2236	72·3
137–144	5929	2581	77·0	5436	2346	75·9
145–152	6033	2685	80·1	5569	2479	80·2
153–160	6237	2889	86·2	5669	2579	83·4
161–168	6274	2926	87·3	5831	2741	88·7
169–176	6312	2964	88·5	5915	2825	91·4
177–184	6434	3086	92·1	6146	3056	98·8
185–192	6458	3110	92·8	6242	3152	102·0
193–200	6664	3316	99·0	6319	3229	104·4
201–208	6709	3361	100·3	6475	3385	109·5
209–216	6734	3386	101·1	6467	3377	109·2
217–224	6798	3450	103·0	6677	3587	116·0
225–232	6778	3430	102·4	6721	3631	117·5
233–240	6886	3538	102·6	6770	3680	119·0

The third method, giving the percentage deficit of the average weights of the babies fed upon boiled cows' milk as compared with the breast-fed babies, shows that at no period of life does the deficit exceed 10 per cent., and that during the greater part of the period under observation the deficit is much less (see Table IX.).

It is probable that this favourable result is largely due to the fact that these babies were attending the consultation, and were therefore under favorable conditions. It is a more favorable result than the majority of the results that have been obtained in the feeding

experiments upon animals who received the milk of a foreign species. The results of clinical experience and the evidence given in Parts II. and III. of this report, render it doubtful whether this result could be surpassed by feeding babies upon raw cows' milk.

Table IX.

Showing the percentage relationship between the average weights of the babies of the two series.

Series I. consisting of breast-fed babies, and Series II. consisting of babies fed upon boiled cows' milk.

Age in days.	Average weight in grammes.		Difference (in grammes).	Percentage value of Series II to Series I.
	Series I.	Series II.		
1–8	3,185	3,515	—330	110·3
9–16	3,348	3,090	258	92·2
17–24	3,507	3,358	149	95·7
25–32	3,746	3,472	274	92·6
33–40	3,939	3,708	231	94·1
41–48	4,119	3,848	271	93·4
49–56	4,291	3,991	300	93 0
57–64	4,443	4,082	361	91·8
65–72	4,638	4,240	408	91·4
73–80	4,737	4,407	330	93·0
81–88	4,937	4,486	451	90·8
89–96	5,079	4,628	451	91·1
97–104	5,191	4,814	377	92·7
105–112	5,380	4,935	445	91·7
113–120	5,566	5,052	514	90·7
121–128	5,659	5,171	488	91·3
129–136	5,757	5,326	431	92·5
137–144	5,929	5,436	493	91·6
145–152	6,033	5,569	464	92·3
153–160	6,237	5,569	568	90·8
161–168	6,274	5,831	443	92·9
169–176	6,312	5,915	397	93·7
177–184	6,434	6,146	288	95·5
185–192	6,458	6,242	216	96·6
193–200	6,664	6,319	345	94·8
201–208	6,709	6,475	234	96·5
209–216	6,734	6,467	267	96·0
217–224	6,798	6,677	121	98·2
225–232	6,778	6,721	57	99·1
233–240	6,886	6,770	116	98·3
241–248	6,891	7,010	—119	101·7
249–256	7,118	7,112	6	99·9
257–264	7,276	7,204	72	99·0
265–272	7,217	7,274	—57	100·7

Note.—After this age the percentages are very variable.

Further analysis of a portion of the material.—It seemed desirable to investigate the average weights of the babies whose weight-charts and notes had been copied for the purposes of this report, in order to get two series, one consisting of babies exclusively breast-fed, and the other consisting solely of babies who had never been breast-fed, but who had been fed from birth upon boiled cows' milk only.

The charts were re-sorted, and it was found that among the babies of the breast-fed series, there were 130 whose records were available from about a fortnight after birth up to at least the 200th day of life, and who during this period had received only breast milk.

Among the 204 babies who had been fed upon boiled cows' milk there were 78 who had attended the consultation during the same period of life and who had received only boiled cows' milk. In addition there were 41 babies who had similar attendance records, and who had been fed for periods of not more than eight days upon the breast before receiving boiled cows' milk, as their sole food.

In order to ascertain whether these 41 babies could reasonably be included in one series with the babies who had never been breast-fed, the average weights for the 78 babies who had never been breast-fed and the average weights for those 41 babies who had received the breast for these few days, were worked out separately. No appreciable difference in the average weights was found, so the two sets of babies were added together, and worked up as a series of 119 babies who had been fed exclusively upon boiled milk. The figures for the 78 and 41 babies respectively are given in Table X.

Table X.

Showing the average weights and the number of estimations of 78 *babies who were never breast-fed, and of* 41 *babies who were breast-fed for eight days or less.*

Age in days.	78 babies never breast-fed.		41 babies breast-fed 1–8 days.	
	Average weight.	Estimations.	Average weight.	Estimations.
1–8	3,350	3	4,325	2 (same baby)
9–16	3,020	17	3,200	9
17–24	3,350	39	3,261	20
25–32	3,485	56	3,245	26
33–40	3,686	55	3,225	35
41–48	3,770	59	3,668	35
49–56	3,888	57	3,906	36
57–64	3,995	68	3,781	34
65–72	4,095	66	4,198	33
73–80	4,254	67	4,348	32
81–88	4,424	86	4,342	40
89–96	4,555	81	4,543	29
97–104	4,769	72	4,787	39
105–112	4,810	65	4,757	38
113–120	4,985	66	4,820	41
121–128	5,073	63	5,020	41
129–136	5,314	68	5,234	33
137–144	5,393	58	5,132	41
145–152	5,483	56	5,526	41
153–160	5,551	58	5,573	31
161–168	5,427	60	5,748	34
169–176	5,816	63	5,803	34
177–184	6,025	49	5,959	33
185–192	5,861	64	5,941	26
193–200	6,295	50	6,335	31

The figures obtained by estimating the average weights of the 130 exclusively breast-fed babies and of the babies fed exclusively upon boiled cows' milk, show the same main characteristics as the curves of the two original series of babies the results of which series were plotted in Diagram I. The divergence is somewhat more accentuated, but the tendency for the two curves to approach one another after about the 200th day, begins to appear after about the 160th day.

The number of observations for the first eight-day period are too small in the case of the babies fed upon boiled cows' milk to merit any special consideration. The average weights are given on Table XI. and the results are plotted in Diagram IV.

Table XI.

Showing the average weight of 130 *Babies exclusively breast-fed up to* 200 *days of age, and of* 119 *Babies of whom* 78 *had never been breast-fed, and of* 41 *who were breast-fed for less than eight days.*

Age in days.	Breast-fed babies.		Babies fed on boiled milk.	
	Average weight (in grammes).	No. of observations.	Average weight (in grammes).	No. of observations.
1–8	3,019	13	3,740	5
9–16	3,325	42	3,083	26
17–24	3,499	71	3,320	59
25–32	3,738	91	3,409	82
33–40	3,955	87	3,682	90
41–48	4,171	103	3,732	94
49–56	4,327	85	3,895	93
57–64	4,506	107	3,923	102
65–72	4,760	103	4,129	99
73–80	4,836	99	4,284	99
81–88	5,102	102	4,398	126
89–96	5,153	98	4,552	110
97–104	5,360	91	4,775	111
105–112	5,530	95	4,791	103
113–120	5,688	98	5,016	105
121–128	5,808	95	5,052	104
129–136	5,020	82	5,288	101
137–144	6,085	97	5,285	99
145–152	6,229	84	5,501	97
153–160	6,272	81	5,559	89
161–168	6,294	67	5,716	94
169–176	6,381	84	5,811	97
177–184	6,597	71	5,999	82
185–192	6,620	67	5,884	90
193–200	6,856	64	6,310	81

The *percentage rate of growth* of the babies of these two series was calculated up to the day at which they doubled their weight, starting from the second eight-day period. Both the breast-fed babies and the babies fed upon boiled cows' milk doubled their weight at the 193–200th day of life. The rate of growth as shown by the figures giving the percentage increase is rather more rapid

DIAGRAM IV.

SHOWING THE AVERAGE WEIGHT OF 130 INFANTS EXCLU-SIVELY BREAST-FED & OF 119 INFANTS EXCLUSIVELY FED UPON BOILED MILK UP TO 200 DAYS OF AGE. OF THE 119 INFANTS 78 HAD NEVER BEEN BREAST-FED AND 41 HAD BEEN BREAST-FED FOR 8 DAYS OR LESS.

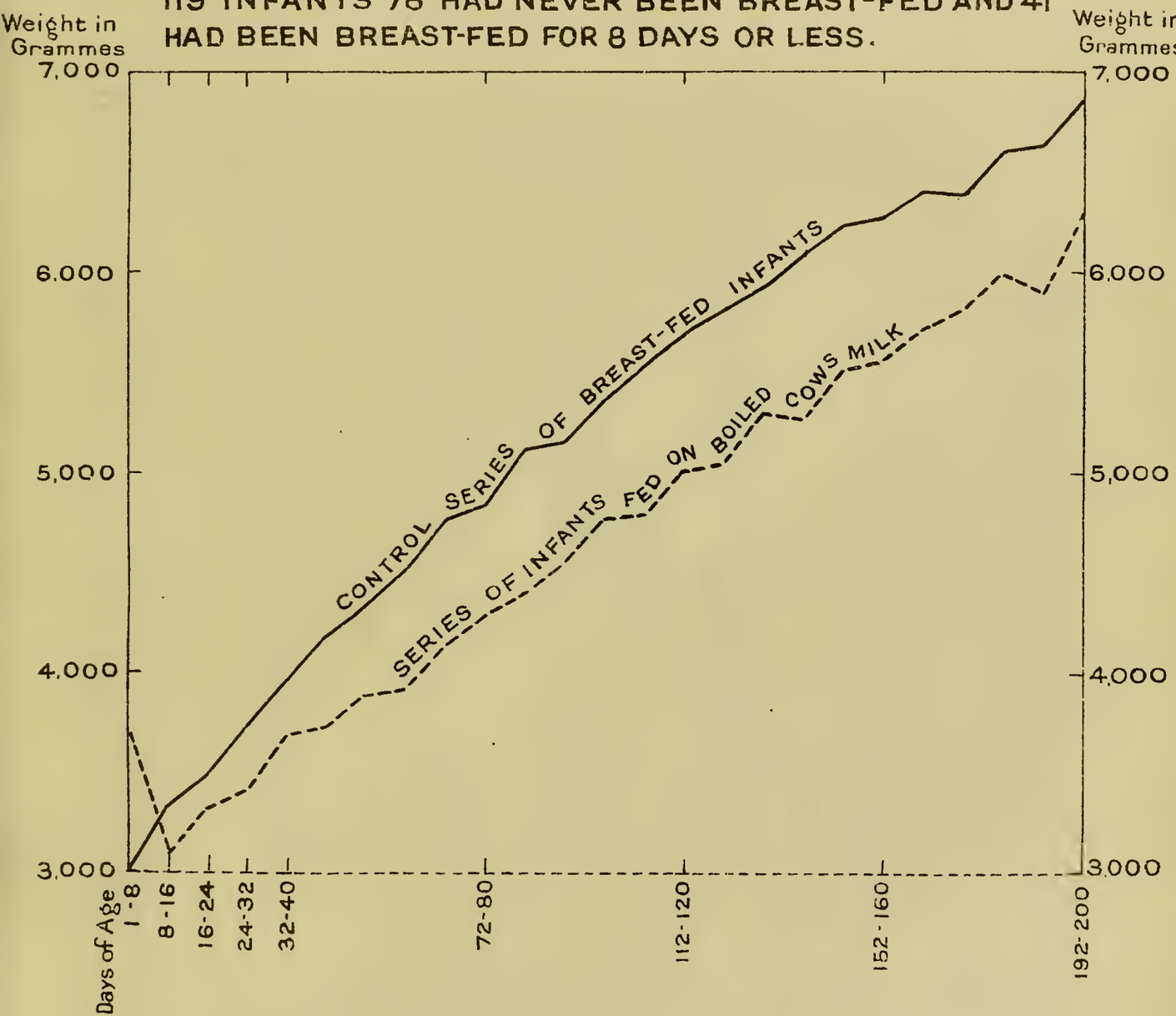

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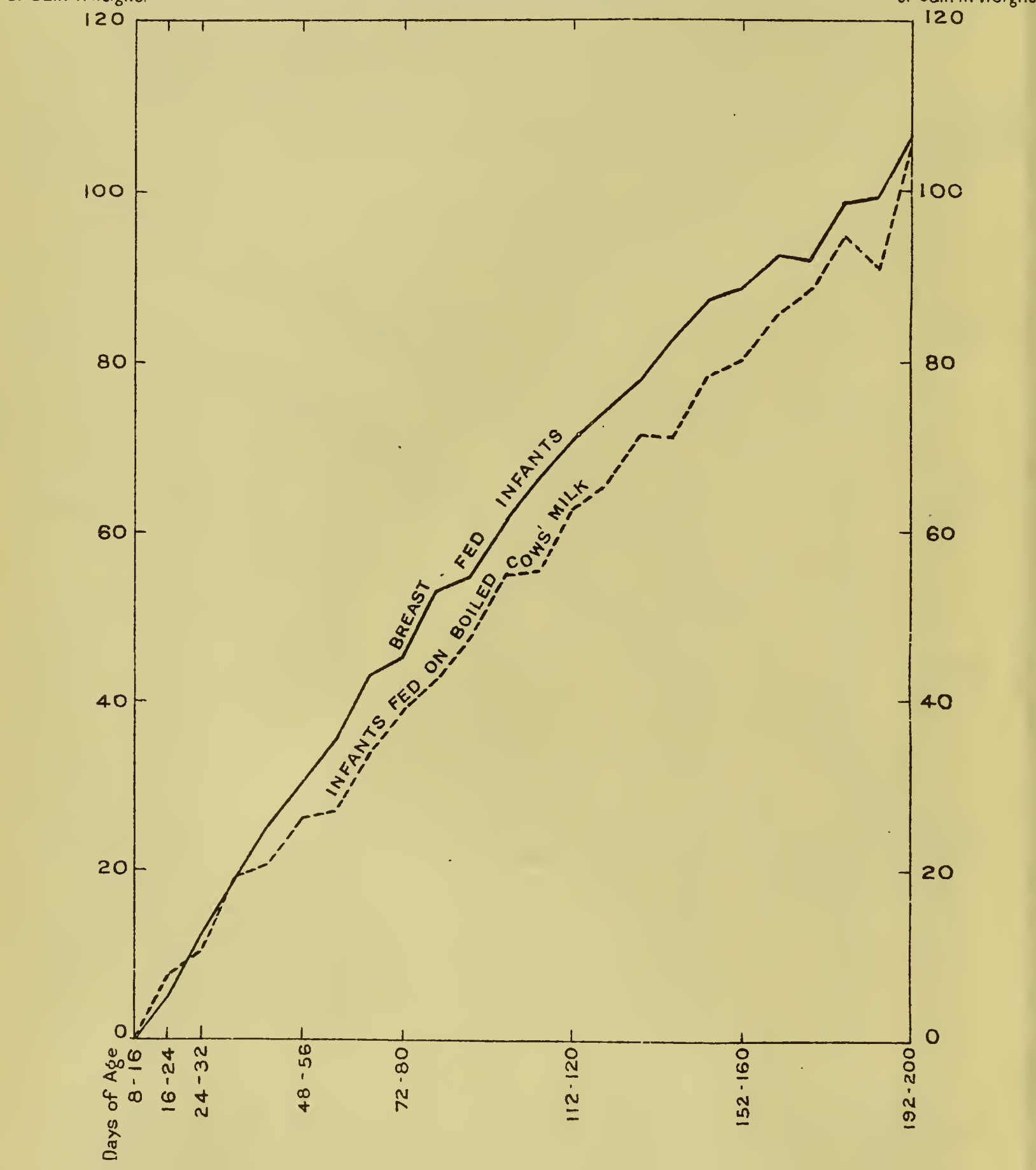
DIAGRAM V.

SHOWING THE PERCENTAGE RATE OF GROWTH OF 130 INFANTS EXCLUSIVELY BREAST-FED & OF 119 INFANTS EXCLUSIVELY FED ON BOILED MILK, STARTING FROM THE 16TH DAY OF LIFE UP TO THE AGE AT WHICH THE WEIGHT WAS DOUBLED.



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in the series of breast-fed babies, than in the series of babies fed upon boiled cows' milk. The figures are given in Table XII. and are plotted in Diagram V.

Table XII.

Showing the percentage rate of growth of the 119 *babies who had never been breast-fed, and of the* 130 *babies who were exclusively breast-fed, starting from the average weight at the end of the sixteenth day of age, and continuing up to the time at which they doubled their weights.*

Age in days.	Breast-fed Babies.			Babies never breast-fed.		
	Average Weight (in grammes).	Increase.		Average Weight (in grammes).	Increase.	
		In grammes.	Per cent.		In grammes.	Per cent.
9–16	3,325	—	—	3,083	—	—
17–24	3,499	174	5·23	3,320	237	7·68
25–32	3,738	413	12·42	3,409	326	10·57
33–40	3,955	630	18·94	3,682	599	19·42
41–48	4,171	846	25·44	3,732	649	21·05
49–56	4,327	1,002	30·13	3,895	812	26·33
57–64	4,506	1,181	35·51	3,923	840	27·24
65–72	4,760	1,435	43·15	4,129	1,046	33·92
73–80	4,836	1,511	45·44	4,284	1,201	38·95
81–88	5,102	1,777	53·44	4,398	1,315	42·65
89–96	5,153	1,828	54·97	4,552	1,469	47·64
97–104	5,360	2,035	61·20	4,775	1 692	54·88
105–112	5,530	2,205	66·31	4,791	1,708	55·40
113–120	5,688	2,363	71·06	5,016	1,933	62·69
121–128	5,808	2,483	74·67	5,052	1,969	63·86
129–136	5,920	2,595	78·04	5,288	2,205	71·52
137–144	6,085	2,760	83·00	5,285	2,202	71·42
145–152	6 229	2,904	87·33	5,501	2,418	78·45
153–160	6 272	2,947	88·63	5,559	2,476	80·31
161–168	6,394	3,069	92·30	5,716	2,633	85·40
169–176	6,381	3,056	91·90	5,811	2,728	88·48
177–184	6,597	3,272	98·40	5,999	2,916	94·58
185–192	6,620	3,295	99·09	5,884	2,801	90·85
193–200	6,856	3,531	106·19	6,310	3,227	104·67

Summary of Results obtained in Part IV.—The Berlin figures dealt with in this part of the report show that, given circumstances similar to those of the Consultation from whence the figures are taken—

(1) Infants fed upon the breast show a higher average weight than infants fed upon boiled cow's milk, up to about the 180–220th day of life. After this age the difference in average weight disappears.

(2) This difference must be attributed to the method of feeding, and not to differences in the social condition of the infants.

(3) The difference in average weight is most marked in the first 16 days of life; this difference must be attributed to the different method of feeding, and not to any possible "error of sampling."
(4) After the first 16 days the average increase in body-weight is almost identical in both series of babies.
(5) The deficit of average weight of the babies fed upon boiled cows' milk below those fed upon the breast, does not reach 10 per cent. at any period.

Part V.—Summary and Conclusions.

The balance of evidence both experimental and clinical points in the main to the same conclusions. Both lines of research show—

(1) That there is apparently no serious loss of nutritive value produced by feeding an animal upon boiled milk derived from an animal of the same species. At the same time it must be pointed out that the published evidence on this point is scanty.
(2) That, when an animal is fed upon the milk of another species, the milk from which has been found to be suitable for this purpose, such small differences as have been found in the nutritive values of raw and boiled milk have been in favour of boiled milk.
(3) That the milk of the same species has a considerably higher nutritive value for that species than the milk of any other species so far investigated.

The evidence dealt with throughout this report emphasises very forcibly the importance of breast-feeding for the young of all species and shows the special importance of breast-feeding during the early weeks of life.

Where artificial feeding has been employed in animal experiments, boiled milk of a foreign species has given more satisfactory results than similar milk raw. The Berlin figures dealing with infants fed on boiled cows' milk, give extremely favourable results, and in view of the evidence collected in this report could scarcely be expected to be surpassed had raw cows' milk been used.

It may be again pointed out that the Berlin babies who are artificially-fed in connection with the consultation receive milk of a known excellent quality. The excellence of the results obtained in Berlin are almost certainly largely due to the care and supervision exercised at and through the consultation.

The foundations of the information given in this report were obtained by me, when working at the Lister Institute as Jenner Research Scholar, during which period I was also sent abroad to study the methods used in the countries of the Continent in the prevention of infantile mortality, especially in connection with the feeding of infants.

The Berlin material was obtained specially for this report to the Local Government Board.

Bibliography.

1. Bamburg. Zur Frage der Rohmilch Ernährung.
   Jahrb. f. Kinderh. Vol. 71, 1910, p. 670.
2. Bang, B. The Fight against Tuberculosis in Denmark. (In French.) Geneva. 1895.
3. Bartenstein. Beiträge zur Frage des künstlichen Morbus Barlow bei Tieren.
   Jahrb. f. kinderh. Vol. 61, 1905, p. 22.
4. Bendix. Uber die Verdaulichkeit der sterilisierten und der nichtsterilisierten Milch.
   Jahrb. f. Kinderh. Vol. 38, 1894, p. 393.
5. Birk. Beiträge zur Physiologie des neugebornen Kindes.
   Monats. f. Kinderh. Vol. 9, 1911, p. 595.
6. Bolle. Zur Therapie der Barlow 'schen Krankheit.
   Zeit. f. Diät. Therapie. Vol. 6, 1903, p. 354.
7. Bourdillon. Rapport de la Commission de la Maladie de Barlow. Revue medicale de la Suisse Romande. Jan., 1908.
8. Brückler. Zwei Ziegenfutterungsversuche mit roher und gekochter Kuh-Milch.
   Jahrb. f. Kinderh. Vol. 66, 1907, p. 373.

   Brüning. Vergleichende Studien uber den Werth der natürlichen und künstlichen Säuglingsernährung bei Tieren.

9. (1) Wiener Klin. Rundschau. Vol. 27, 1904, pp. 481, 503, 521, 539, 556.
10. (2) Münch. Med. Wochens. Vol. 52, 1903, p. 369. Beiträge zur Lehre der natürlichen und künstlichen Säuglingsernährung.
11. (3) Zeitsch. f. Tiermed. Vol. 10, Heft 2 and 3, 1906.
12. Budin. (1) Le Nourisson. Paris. Translated into English, 1907.
13. (2) Manuel Pratique d'Allaitement. Paris, 1907.
14. Bunge. Die zunehmende Unfähigkeit der Frauen zu Stillen. München, 1909.
15. Bresset. Rapport de la Dispensaire Gratuite de la Caisse des Ecoles, du VIIième Arrondissement. Statistique de 1888–1905, pp. 25, 26.
16. Carel. Un cas de scorbut imputable au lait sterilisé consumé trop longtemps après la sterilisation.
   Bull. de la Soc. de Pediatrie. Paris, Jan., 1910.
17. Camerer. Das Gewicht- und Langenwachsthums des Menschen.
   Jahrb. f. Kinderh. 1901. Vol. 53, p. 403.
18. Chamouin. Valeur et effets comparés du lait cru et du lait bouilli.
   Revue Scientifique. 1892. Vol. 24, p. 91.
19. Cheadle. Three cases of scurvy supervening on rickets in young children.
   Lancet. Nov., 1878, p. 685.
20. Czerny-Keller. Des Kindes Ernährung, Ernährungsbedingungen, und Ernährungs-Therapie. Vol. I, p. 528.

21. Czerny. Rohe Milch als Sauglingsnahrung.
Centralb. f. Stoffweschsel u. Verdauungskrankheiten. 1902. Vol. 3, p. 93.
22. Davis and Leeds. On the clinical Value of Sterilised Milk.
Amer. Journ. of Medical Science, 1891, p. 560.
23. Dean, H. H. Pasteurised v. Raw skim Milk for calves.
Report of the Ontario Department of Agriculture, 1898, Vol. I., p. 66.
24. Doane and Price. Maryland Agric. Exp. Stat. Bulletin, 77, 1901, and Zeit. f. Unters. Nahrung u. Genussm., 1903.
25. Escherich. Wiener Klin. Wochens. Vol. 13, 1900, p. 1,185.
26. Feer. Weitere Beobachtung über die Nahrungsmenge von Brustkindern.
Jahrb. f. Kinderh. Vol. 56, 1902, p. 421.
27. Fetra, la. Infantile Scurvy.
Amer. Journ. of Med. Sci. June, 1907,
Finkelstein.
28. (1) Die rohe Milch in der Säuglingsernährung.
Therap. Monatsh. Oct. 1907.
29. (2) Sammelreferate.
Therapie der Gegenwart. 1904.
30. (3) Die Waisensäuglinge Berlins.
Berlin. 1904.
31. Flügge. Die Aufgaben und Leistungen der Milchsterilisierung.
Zeit. f. Hyg. Vol. 17, p. 272.
32. Forsyth. The History of Infant Feeding from Elizabethan times.
Proc. of the Roy. Soc. of Med. Feb. 1911.
33. Gerlach. Verfütterung von gekochter Milch an Kälber.
Landwirtschaftliche Presse 1901 Vol. 28, p. 160.
34. Greenwood and White. Biometrika. VII., 1910, pp. 505 et seq.
35. Gittings and Griffith. The weight of breast-fed infants.
Arch. of Ped. May, 1907.
36. Halipré. Le lait cru dans l'allaitement des nourissons.
Revue mens. des mal. de l'Enfance. Vol. 22, 1904, p. 405.
37. Hittcher. Kalberfütterungsversuche.
Landwirtschaftliche Jahrbücher. 1909.
38. Hohlfeld. Uber rohe Milch als Säuglingsnahrung.
Jahrb. f. Kinderh. Vol. 62, 1905, p. 22.
39. Keller. Futterungsversuche an Mäusen mit hochsterilisierter Milch.
Zeit. f. Diät. Therapie. Vol. 7, 1904, p. 90.
40. Koplik. The nutrition of infants fed upon raw, boiled, pasteurised, and sterilised milk.
New York Medical Journal. Vol. 61, 1895, p. 455.
41. Lane-Claypon. Observations on the Influence of heating upon the nutritive value of milk, etc.
Journ. of Hyg. 1909. Vol. 9, p. 233.
42. Langstein-Meyer. Säuglingsernahrung und Säuglingsstoffweschsel.
Wiesbaden. 1910.

43. Lange. Uber den Stoffweschsel des Säuglings bei Ernährung mit Kuhmilch.
Jahrb. f. Kinderh. Vol. 39, 1895, p. 216.
Leeds and Davis. (*See* Davis.)
44. Lust. Six cas de scorbut infantile en trois mois.
Arch. de med. des Enfants. Feb. 1911, Vol. 14, p. 119.
45. Malthus. Essay on Population. Book. II., chap. VIII., and Bk. IV., chap. VIII.
46. Meyer, L. F. Beiträg zur Kenntniss der Unterschiede zwischen Frauen und Kuhmilch-ernährung. Monats f. Kinderh. 1906. Vol, 5, p. 361.
Meyer-Langstein. (*See* Langstein.)
47. Monrad. Uber Benutzung von roher Milch bei Atrophie und chronischen Magen-und Darmkatarrh bei Säuglingen.
Jahrb. f. Kinderh. 1902. Vol. 55, p. 62.
48. (1) Moro. Experimentelle Beiträge zur Frage der künstlichen Säuglingsernährung, Munch. Med Wochens, Vol. 45, 1907.
49. (2) Die Fermente der Milch. Jahrb. f. Kinderh. Vol 56, 1902, p. 391.
50. Müller, E. Beiträge zur Frage der natürlichen Schutzstoff in der Frauenmilch. Berl. Klin Wochens, 1908, p. 1,058.
51. Newsholme. Supplement to the 39th Annual Report to the Local Government Board, 1910.
52. Palmer. Feeding the infants of the poor with unsterilised cows' milk. New York Med. Journ. Vol. 72, 1900, p. 404.
53. Pearson, K. Biom. VII, 1909, p. 96.
54. Plantenga. Über rohe Milch.
(1) Gesell. für Kinderh. February, 1910.
(2) Meeting of the Netherlands Society for Pediatrics. Cologne, 1910.
55. Potpeschnig. Ernährungsversuche an Säuglinge mit erwärmter Milch. Munch. Med. Wochens, 1907. Vol. 27, p. 1,326.
Price and Doane. (*See* Doane.)
56. Price. The comparative digestibility of raw, pasteurised and sterilised milk. New York Med. Journ. Vol. 79, 1904, p. 405.
57. Pröscher. Die Beziehung der Wachsthumsgeschwindigkeit des Säuglings zur Zusammensetzung der Milch, bei verschiedenen Säugethiere. Zeitsch. f. Physiol. Chemie. Vol. 24, 1898, p. 285.
58. Rodet.—Sur la valeur nutritive du lait sterilisé. C.R. de la Soc. de Biol. Vol. 48, 1896, p. 555.
59. Schlossmann. Zur Frage der natürlichen Säuglingsernährung. Arch f. Kinderh. Vol. 30, 1900, p. 288, and Vol. 33, 1902, p. 338.
60. Silbergleit. Hyg. Rund. Über die Statistik der Säuglings und Säuglingssterblichkeit. Vol. 21, 1911.
61. "Student." Biom. VI, 1908, pp. 1–28.
62. Uhlig. Über Versuche einer Ernährung kranken Säuglinge mit sterilisierter Milch. Jahrb. f. Kinderh. Vol. 30, 1891, pp. 81 and 105.

VARIOT.

63. (1) Sur le traitement de l'atrophie infantile par l'emploi du lait sterilisé. Bull. de la Soc. Med. des Hop. de Paris. Vol. 15, 1898, p. 757.

64. (2) Report of the Consultation at Belleville. Contes Rendus. Vol. 139, 1904, p. 1,002.

VINCENT.

65. (1) Clinical Studies on the nutritional disorders of Infancy. London, 1906.

66. (2) The intestinal Toxoemia of Infants. London, 1911.

67. WHITE and GREENWOOD. (*See* Greenwood,)

68. YULE. An Introduction to the Study of Statistics. London, 1911.